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An introduction to the Socially Responsible Behaviour through Embodied Thinking (SORBET) Project as a response to COVID-19

Kenneth Y T LIM*, Swee Ling LEONGb & Ahmed Hazyl HILMYc
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Abstract: This paper describes an intervention piloted in secondary schools in Singapore in the second half of 2020, in response to the COVID-19 pandemic. The intervention aims to afford learners more authentic understandings of the need to invest effort and self-discipline in nurturing the new habit of practicing safe-distancing, beyond just doing so because of public exhortation. It seeks to achieve this objective through two complementary halves, the first being an activity within a virtual environment during which a (virtual) virus is diffusing, and the second being dialogue and discussion around students’ decision-making and behaviours, as informed from an analysis of data of interaction from the first half, via a web-based interface. In this way, the Socially Responsible Behaviour through Embodied Thinking (SORBET) Project represents not only an intervention designed to meet the challenges to learning imposed by COVID-19, but also one of the current few which attempt to do so by leveraging students’ evolving conceptions about the diffusion of a virus amongst a population. Understood thusly, the intervention has potential curricular applications in a number of disciplinary domains, such as in mathematics, geography, biology and citizenship education.

Keywords: virus diffusion, multi-disciplinary learning, embodied cognition, dialogic interaction

1. Introduction

The novel coronavirus and the disease COVID-19 has caused disruption on a global scale in 2020 from a variety of frames, including economic, sociological, infrastructural and political. From the perspective of school-going children, they have also experienced other aspects of changes to their daily routine, in terms of (say) their parents and caregivers working from home. These experiences would have brought home the realities of life changed under COVID-19 to the students, even if they may not yet fully comprehend the nature of what viruses are and the ways in which they may spread through communities. From a sociological perspective, there have been anecdotal instances of adolescents and older students not taking recommended protocols of safe distancing sufficiently seriously (for example, National Post Canada 2020 and CNN 2020).

In the context of day-to-day interactions with others in a time of COVID-19, the fundamental problematic which the Socially Responsible Behaviour through Embodied Thinking (SORBET) environment seeks to address is the disconnect between everyday interaction (and the decision-making processes underlying it) with feedback on our action and decisions (with respect to the practice of social responsibility) which presently comes the following day through the publication of case numbers. This feedback suffers from (a) a time lag, and (b) a lack of context - the feedback is general to the population as a whole and not particular to the decisions and actions of any given individual / learner.

Further, there is currently no practical way of visually augmenting the ‘safe’ radius of interaction - this is especially important to younger learners, though sometimes adolescents also need timely reminders. Thus, for example, some students in China wear ‘one-metre-hats’ (Figure 1 below), but this is not practicable on a daily basis.
Figure 1. ‘One-metre hats’ as augments to safe-distancing in a Chinese school.

2. Review of literature

There are currently few resources targeted specifically to help students (and the general populace) better understand the probabilistic nature of the diffusion of viruses. Some are text-based print media (for example, Smithsonian Institution, 2020), and others are web-based (for example, Washington Post, 2020). Both print-based and web-based learning resources have been designed from the paradigm of a virtual laboratory setting. As argued by Bailey, Bailenson, and Casasanto (2016), there is empirical evidence that the human mind tries to replicate and mimic grounded experiences with concrete outcomes, from knowledge gains to emotions. Gee (2003), has written about the role of what he has termed Projective Identity in game-based learning. Briefly, Gee describes how – in well-designed learning environments – a learner might potentially develop a Projective Identity as an amalgam which complements both his or her atomic (human) identity and the virtual (avatar) identity, and how such Projective Identities might persist beyond the instantiations of the game and / or the immersive environment to influence values and behaviours in other (non-game) contexts. Gee’s thesis thus speaks directly towards the present critique that might be levelled against these - admittedly very early - attempts at helping make the probabilistically-driven mechanics of virus diffusion more intelligible to lay audiences. Central to Gee’s thesis is an understanding of the role of embodied cognition in learning. Embodied cognition has its origins in the respective work of Vygostsky (1978) and Gibson (1979). It can be defined as the involvement of multiple senses for enriching immersion and understanding (Mahon (2015), Clark (2017)). The term refers to the idea that body and senses are not peripheral components of our thinking, instead being structuring parameters operating with respect to one's material environment, situation, and timing (Barsalou (2010); Shapiro (2011); Clark (ibid)). This stance of embodied cognition is supported by work in neuroscience. Ratey (2001), for example, has described how emotional impulses are transmitted directly to the amygdala and the insula; these – in turn – lead to actions in the motor system. In sum, mediations at both the individual and social levels involve thought, action and emotion. The three form mutually complementary facets in understanding learning. In this framing, meanings are appropriated through such mediations. Emotion is an integral part of the experience from which subsequent meaning-making is based. Understood thusly, intuitions gradually develop into scientific concepts; conversely, scientific concepts are translated to reflexive action. The construct of embodied cognition with respect to mathematics education has been elaborated in Núñez, Edwards, and Matos (1999) and has acquired an increasing popularity because of its relation with technology such as virtual reality and smart interfaces (Mahon (ibid); Amin, Jeppsson, and Haglund (2015)). For example, recent work by Miller et al (2019) has suggested that social interactions in virtual
augmented environments do persist in influencing human behavior even after the actual intervention has ended. The preceding discussion is summarized in Figure 2 below.

Figure 2. Theoretical stance of the SORBET approach with respect to long-term dispositional change.

It was this theoretical perspective that the team authoring the present paper conceptualised a learning environment (SORBET) in an open-source immersive world (OpenSim), in which the acronym SORBET stands for Socially Responsible Behaviour through Embodied Thinking. The environment was informed by curriculum design principles of the Six Learnings framework (Lim, 2009) in order to help learners experience, tinker with, and discuss probabilistically-driven scenarios of virus diffusion in an intelligible, embodied, manner.

3. Description of intervention

The SORBET environment comprises two complementary halves, both or either or which may be conducted in face-to-face / remote-learning / home-based learning / blended learning contexts (or, any combination thereof). For example, it has low network infrastructural requirements through an architecture known as ‘Sim-on-a-Stick’ (for example, students in a class may participate concurrently and collaboratively by having the environment instantiated on a portable USB thumb-drive and connecting only to a local network within the classroom (http://www.simonastick.com/)). Importantly, this same multi-player environment has also been designed such that participants need not be co-located in order to take part concurrently in an activity (such as learning during home-based confinements and similar contexts). In such a scenario, the environment would be hosted on an open-source cloud-sharing platform (or similar), with learners logging in remotely; post-activity discussion would be conducted via Microsoft Teams / Zoom, or similar. From a public health perspective, the mathematical principles undergirding modelling the geographical diffusion of disease are generally based around trying to understand the nature of how a given population transitions among three main states, namely: individuals are susceptible (S) to the virus; become infected (I); and then either recover (R) or die. The design decision was made that each student would have an equal chance of catching the virus from an
infecteed person because the population is perfectly and evenly mixed, and that people with the disease are all equally infectious. The SORBET approach was conceptualised and designed in April 2020 and piloted among pupils during mathematics lessons in three secondary schools in Singapore in the second half of the year, from July. The schools planned to enact the intervention in face-to-face settings as part of the formal classroom curriculum. At the time of writing (August 2020) one of the schools has enacted the activity with Grade 8 pupils (n = 105). Data from this enaction is still being analysed. Each intervention during the pilot is played through five cycles, the duration of which is customisable. Prior to the activity, teachers discuss with students the degree of infective aggression that they wish to explore, with a view to deciding upon a value for the infection condition / ‘contagion sum’. During the activity, students – through their avatars – explore a virtual environment in either a free-form or semi-structured manner, depending on their learning needs. Colour-coded discs will momentarily appear around each avatar from time to time, indicating if one’s personal safe radius is being infringed upon. When students’ avatars come in to proximity with others, each participant interaction is recorded and assigned a random number. Should that number be equal to the contagion sum, the participant is considered ‘infected’. The virtual environment in which they interact through exploration is designed to resemble a typical neighbourhood of Singapore, with a high-rise block of ‘public housing’, a children’s playground, and other simple landscaping elements. Should teachers feel that students might need an incentive to explore it – and thus interact with each other – simple game-link activities might be incorporated such as encouraging students to scavenge the environment for hidden tokens (in such a case, these tokens would have no direct bearing on the outcome of the diffusion of the virus and are simply emplaced in the environment should teachers feel students need encouragement to explore). At the end of each cycle, the system records the state of the activity, namely: the newly infected avatars, and the total number of infected. The end of the activity within the immersive environment marks the transition from the first – embodied – half of the SORBET approach to the second half. For this second – dialogic – half, the teacher and the learners have the opportunity to access and examine the (simulated) ‘infection data’ through a web-based dashboard, designed in accordance with worksheets put together by teachers in a Networked Learning Community at the Academy of Singapore Teachers. Teachers may facilitate the interpretation of the interaction data and encourage students to ‘unpack’ and discuss their observations and emerging hypotheses, in either face-to-face or online settings. In this way, the concerns raised in the Introduction of this paper are addressed, and participants are able to receive immediate feedback on their decision-making behind their actions, in a way which is not yet practicable in ‘real world’ settings. Over the long run, SORBET seeks to nurture the disposition of learners taking responsibility for their actions, in the social context of an epidemic / pandemic. Human agency therefore lies at the heart of the SORBET Project. With its emphasis on learner agency and ownership of their behaviours, learning in SORBET is active and embodied. This is congruent with the argument advanced by Bailey, Bailenson and Casasanto (2016) that there is empirical evidence that the human mind tries to replicate and mimic grounded experiences with concrete outcomes, from knowledge gains to emotions. The preceding discussion is summarized in Figure 3 below.
4. Concluding remarks

This paper has described work-in-progress with respect to the design and enactment of an open-source immersive environment with a view to its use in mathematics education, with particular emphasis on helping learners have a more embodied understanding of the probabilistically-driven mechanics of virus diffusion, in contexts of learning in which the learners are not necessarily co-present. While its original use was in the disciplinary domain of mathematics, the SORBET Project would also support curricular links to other subjects such as geography (spatial diffusion), biology (epidemiology of disease) and citizenship education (positive social values). Such applications can be actively explored in future. At the time of writing (August 2020), data (such as how students respond to the intervention) from the piloting is still being collated and cannot be reported in this paper at the present juncture. Some data may be shared during the workshop within which this paper situates itself. The environment itself is designed to be scalable and designed to be easy to implement with low network infrastructure requirements. In this, it is hoped that – from the theoretical lens of Gee’s (2003) Projective Identity – learners in a variety of contexts of learning (be they face-to-face, or remote learning online) will not only come away with an authentic appreciation of probabilistically-driven virus diffusion, but also with an affective appreciation of the need to practice safe distancing during the Covid-19 pandemic. In this way, it is our hope that our work contributes to the theme of the workshop within which this paper situates itself, namely of the potential role of computer-supported collaborative learning in “rethinking social interaction” during and beyond the COVID-19 pandemic.

References

Social-Distance Education: Struggling with Cognition, Emotion or Motivation during SRL?

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Abstract: The covid-19 pandemic dramatically changed the educational landscape as emergency remote teaching strategies had to be implemented almost worldwide changing educational practices and reducing student-teacher contact. This comes with many challenges for students, who had to rely on their self-regulatory skills more than ever. To get an overview over challenges connected to social-distance education, we conducted a survey study (N = 119) to find out more about self-regulatory challenges students face during this digital semester. The results show that students seem to rate motivational and emotional challenges most severe and to have less issues with cognitive and metacognitive challenges. This has implications on what should be focused on in upcoming (socially distanced) semesters as providing highly structured learning material to foster students’ understanding of the content material may not entirely solve the most pressing challenges for students.

Keywords: Social-Distance Education, Self-Regulated Learning, Higher Education

1. Introduction

The severe impact of the covid-19 pandemic on higher education (HE) and educational practices forced universities worldwide to adapt to the situation by shifting to emergency remote teaching (ERT) under conditions varying severely between and even within states and national boundaries (as pointed out by Reynolds & Chu, 2020a). Recent surveys show teachers and students struggling with technological infrastructure, technology usage and the logistics of the new situation (e.g., Marinoni, van’t Land, & Jensen, 2020). During ERT, teachers provided a wide range of different educational resources and courses often minimising synchronous teaching and relying heavily on asynchronous activities. This not only puts a strain on teachers and technological infrastructures, but it also requires students to conduct their coursework largely at home, often with minimal (or reduced) teacher interference and guidance, making it more pertinent for them than ever to successfully and independently regulate their learning processes.

1.1 Challenges Related to Self-Regulated Learning

Self-regulated learning (SRL) can be described as actively regulating cognitive, behavioural, motivational and affective aspects of learning (Panadero, 2017; Pintrich, 2000) by metacognitively monitoring internal and external conditions and adapting one’s own learning-related activities (Winne & Hadwin, 1998; Winne & Nesbit, 2009). During SRL, learners not only regulate their cognitions and learning activities, but also need to regulate their motivation (Winne & Hadwin, 2012; Zimmermann, 1989). Additionally, affect is more and more regarded as an important factor during SRL (e.g., Efklides, 2011; Efklides, Schwartz, & Brown, 2018). Thus, when studying challenges during SRL, cognitive, metacognitive, motivational, and emotional aspects should be considered. While self-regulated learning processes occur within any given learning situation, challenges learners face vastly depend on instructional support, which may be provided by teachers, peers, or digital learning environments and thus may vary severely across different learning situations. Some situations are particularly challenging with regard to SRL for example when the content is complex and digital learning environments do not offer self-regulatory support (e.g., Azevedo & Cromley, 2004; Azevedo, Moos, Greene, Winters, & Cromley, 2008). Thus, it can be assumed that changes affecting the individual support structures and
the nature of student-teacher interaction during ERT may severely affect the challenges learners perceive with regard to SRL. Cognitive and metacognitive challenges are amongst the most discussed within SRL research as metacognition and SRL are inherently linked and the terms are even sometimes used interchangeably (Dinsmore, Alexander, & Loughlin, 2008). Cognitive challenges may be related to prior knowledge or the availability of cognitive strategies while metacognitive challenges relate directly to regulating cognition and learning. However, empirical research has found that especially motivational challenges are among the most prevalent in HE (Koivuniemi, Panadero, Malmberg, & Järvelä, 2017). For example procrastination, which can be conceptualised as a failure to regulate motivation, may severely affect academic achievement and is related to students’ drop-out intentions (Bäulke, Eckerlein, & Dresel, 2018). But also emotions can play a major role in SRL (Webster & Hadwin, 2015) and especially negative emotions can be a hindrance to academic success on school level (Pekrun, Lichtenfeld, Marsh, Murayama, & Goetz, 2017). Thus, regulating motivation and emotion can be seen as equally important as regulating cognitions and learning activities.

1.2 Research Question

While the current pandemic-related situation poses a lot of questions regarding not only practical issues of ERT (see for example the current special issue on evidence-based and pragmatic online teaching and learning approaches, Reynolds & Chu, 2020b), but also theoretical questions on the nature of HE learning and teaching processes during social-distance education, the question of what learners struggle with during ERT is one of the central questions to answer. Thus, this research aims at identifying rather broadly and explorative what self-regulated-learning related issues university students struggled with most during the “social-distance semester”. While we acknowledge that this depends severely on the structure of courses attended and the personal situation of the students, we hope to identify what issues are most pressing and need to be addressed explicitly in upcoming (socially distanced) semesters.

2. Method

2.1 Design of Questionnaire

In order to answer those questions, we designed a questionnaire relating to challenges of SRL during learning. Building on the issues identified by Koivuniemi and colleagues (2017) and results of the analysis of a small pre-study in a psychology lecture (N = 6), we developed a questionnaire containing 32 items covering a broad selection of items to explorative assess students’ perceived challenges. The items covered topics like cognitive and metacognitive challenges, e.g., regarding comprehension of content, goal setting and planning, or monitoring knowledge and progress, learning tactics and strategies, but also emotional challenges like fears and frustration, and motivational challenges like interest, regulation of concentration, effort and motivation, procrastination, and last but not least, social aspects like teacher-student and peer contact. All items were phrased as statements and answers were to be given using an equal-distant response format ranging from 1 (not at all true) to 6 (completely true). Items were mainly coded as challenges with higher values indicating higher challenges. Seven items were positively coded (higher values indicating less challenging aspects) and therefore recoded for analyses so that high values uniformly indicate challenges being perceived as more severe.

2.2 Sample

The study’s data sample consisted of answers of N = 119 university students studying in Germany who answered the questionnaire online (the original sample consisted of 122 students of which 3 had to be excluded due to incomplete or highly improbable answer patterns). Students were mainly in their 20s with a mean age of 24.6 (SD = 4.6) coming from study courses covering a broad range of subjects with the most frequent being psychology (37, including business psychology), economics or related subjects (32), and cognitive and media sciences (17). 70 (59%) were female, 31 (26%) male and 18 (15%)
preferred not to respond to this question. Participants were recruited via the university’s student forums, social media pages, and advertisement in lectures. They received no compensation for participation.

2.3 Study

The study (ID: psychmeth_2020_VLSRL_07B) was conducted online in June 2020 and approved by the local ethics committee. After an introduction into the aims of the study, participants gave their informed consent and were given the questionnaire to answer. They were informed that there were no right or wrong answers and that they should answer as truthfully as possible. They were not asked to respond to ERT explicitly, but only asked to assess their perceived challenges within the digital learning context of the semester. After completing the SRL-challenges questionnaire, they were asked to provide demographical information, thanked and provided with contact information of the researchers.

3. Results

3.1 Description of Data: Biggest and Smallest Singular Challenges

In a first step, we evaluated each item separately to identify areas with biggest and smallest challenges. Items in general had means between 2.15 and 5.26 (see Table 1). We classified challenges whose 95% CI (3000 percentile bootstrapping) was entirely below 3 as small and, in contrast, challenges whose 95% CI was entirely above 4 as big. The results can be seen in Table 1 (we included borderline items whose 95% CI was equal/below 3.1 or equal/above 3.9). The most severe challenge seems to be missing contact with peers while the least severe seems to be the fit between new content and prior knowledge.

<table>
<thead>
<tr>
<th>Least Challenging (95% CI &lt; 3.00 [ &lt; 3.10])</th>
<th>M</th>
<th>SD</th>
<th>Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>The new content does not fit to my prior knowledge</td>
<td>2.15</td>
<td>1.10</td>
<td>1.96</td>
<td>2.36</td>
</tr>
<tr>
<td>I don’t know why I have to learn these things</td>
<td>2.29</td>
<td>1.16</td>
<td>2.08</td>
<td>2.49</td>
</tr>
<tr>
<td>I lack the prior knowledge to understand the material</td>
<td>2.44</td>
<td>1.11</td>
<td>2.24</td>
<td>2.64</td>
</tr>
<tr>
<td>The topics to be learned are not important to me</td>
<td>2.55</td>
<td>1.20</td>
<td>2.35</td>
<td>2.76</td>
</tr>
<tr>
<td>Handling the technology is frustrating for me</td>
<td>2.53</td>
<td>1.43</td>
<td>2.29</td>
<td>2.79</td>
</tr>
<tr>
<td>I don’t know how to apply my knowledge to solve the tasks</td>
<td>2.73</td>
<td>1.32</td>
<td>2.50</td>
<td>2.98</td>
</tr>
<tr>
<td>[I have trouble understanding the to be learned content]</td>
<td>2.84</td>
<td>1.16</td>
<td>2.64</td>
<td>3.04</td>
</tr>
</tbody>
</table>

Most Challenging (95% CI > 4.00 [ > 3.90])

<table>
<thead>
<tr>
<th>M</th>
<th>SD</th>
<th>Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>[I am worried, because I have so much to do]</td>
<td>4.17</td>
<td>1.45</td>
<td>3.91</td>
</tr>
<tr>
<td>[I have trouble starting with learning]</td>
<td>4.19</td>
<td>1.35</td>
<td>3.95</td>
</tr>
<tr>
<td>I have trouble concentrating</td>
<td>4.27</td>
<td>1.33</td>
<td>4.03</td>
</tr>
<tr>
<td>I have trouble keeping up my motivation</td>
<td>4.31</td>
<td>1.36</td>
<td>4.06</td>
</tr>
<tr>
<td>I miss the personal contact to my student peers</td>
<td>5.26</td>
<td>1.05</td>
<td>5.07</td>
</tr>
</tbody>
</table>

Note: 95% CI are based on 3000 percentile bootstrapping; N = 119; values range from 1 (not true at all → not challenging) to 6 (completely true → challenging); all items are translated from German

3.2 Extracting Factors (Exploratory Factor Analysis)

In a second step, we conducted an exploratory factor analysis with varimax rotation. This analysis was chosen because the item development was partially based on a bottom-up approach covering a broad range of items without a definitive, pre-defined factor structure. The analysis came up with 8 factors with Eigenvalues larger than 1, explaining 69.7 % of the variance. While the amount of factors was no
surprise due to the broad nature of the items, it seemed that (meta-)cognitive issues formed one factor (8 items including challenges related to comprehending the learning content and challenges relating to metacognitively monitoring learning, setting goals or regulating the learning process itself), motivational issues formed a second factor (6 items including issues related to procrastination and the regulation of concentration, effort and motivation), and emotional issues a third one (4 items including fear of failure, worries due to the amount of work and frustration with progress). A fourth factor was related to broader organisational issues of structuring learning (4 items relating to issues of general time management and scheduling, keeping an overview over courses and using one’s known learning techniques during the online semester). The other factors were not readily interpretable and their internal consistency was poor (Cronbach’s α < .6), so we did not pursue them further.

3.3 Forming Scales

Taking the content of the items into account as well as scale reliability, we formed scales based on this analysis. We came up with 5 scales. Since the first factor included items relating to two content-wise very different aspects, we separated these two and formed two cognitive sub-scales with five items each (largely based on factor 1 but including two additional items with high factor loadings on this scale): one relating directly to comprehension and understanding of the content (cogn) and one relating to the learning process and its (metacognitive) regulation (metacogn). A third scale consisted of the items of the second factor and formed a motivational scale (motiva) with six items. The fourth scale consisted of the emotion-related items of factor 3, however, we excluded one item that did not fit content-wise and loaded high on various factors. The resulting scale had three items (emotion). The last scale consisted of three items from factor 4, but we excluded one item that loaded equally high on the first factor and related to monitoring learning and was thus included in metacogn. It can be interpreted as managing the coursework (manage). Altogether, we formed five scales whose descriptive statistics can be viewed in Table 2. It should be noted that some items loaded on various factors and were highly interrelated.

Table 2. Descriptive statistics of the extracted scales

<table>
<thead>
<tr>
<th>Scale</th>
<th>No. of Items</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>95% CI (Mean)</th>
<th>Cronbach’s α</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>lower</td>
<td>upper</td>
</tr>
<tr>
<td>cogn</td>
<td>5</td>
<td>119</td>
<td>2.81</td>
<td>0.87</td>
<td>2.68</td>
<td>2.96</td>
</tr>
<tr>
<td>metacogn</td>
<td>5</td>
<td>119</td>
<td>3.20</td>
<td>1.07</td>
<td>3.01</td>
<td>3.39</td>
</tr>
<tr>
<td>motiva</td>
<td>6</td>
<td>119</td>
<td>3.78</td>
<td>1.04</td>
<td>3.59</td>
<td>3.95</td>
</tr>
<tr>
<td>emotion</td>
<td>3</td>
<td>119</td>
<td>3.90</td>
<td>1.27</td>
<td>3.68</td>
<td>4.13</td>
</tr>
<tr>
<td>manage</td>
<td>3</td>
<td>119</td>
<td>3.51</td>
<td>1.33</td>
<td>3.27</td>
<td>3.75</td>
</tr>
</tbody>
</table>

Note: 95% CI are based on 3000 percentile bootstrapping

Table 3. Pairwise comparisons between the scales

<table>
<thead>
<tr>
<th>comparison (rank_1 vs. rank_2)</th>
<th>rank_1</th>
<th>rank_2</th>
<th>z</th>
<th>p (bonferroni corrected)</th>
</tr>
</thead>
<tbody>
<tr>
<td>cogn vs. metacogn</td>
<td>1.91</td>
<td>2.71</td>
<td>-3.915</td>
<td>.001</td>
</tr>
<tr>
<td>cogn vs. manage</td>
<td>1.91</td>
<td>3.15</td>
<td>6.047</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>cogn vs. motiva</td>
<td>1.91</td>
<td>3.47</td>
<td>7.646</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>cogn vs. emotion</td>
<td>1.91</td>
<td>3.76</td>
<td>9.040</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>metacogn vs. manage</td>
<td>2.71</td>
<td>3.15</td>
<td>2.132</td>
<td>.330</td>
</tr>
<tr>
<td>metacogn vs. motiva</td>
<td>2.71</td>
<td>3.47</td>
<td>3.731</td>
<td>.002</td>
</tr>
<tr>
<td>metacogn vs. emotion</td>
<td>2.71</td>
<td>3.76</td>
<td>5.125</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>manage vs. motiva</td>
<td>3.15</td>
<td>3.47</td>
<td>1.599</td>
<td>&gt; .999</td>
</tr>
<tr>
<td>manage vs. emotion</td>
<td>3.15</td>
<td>3.76</td>
<td>2.993</td>
<td>.028</td>
</tr>
<tr>
<td>motiva vs. emotion</td>
<td>3.47</td>
<td>3.76</td>
<td>-1.394</td>
<td>&gt; .999</td>
</tr>
</tbody>
</table>

3.4 Comparisons
To get a better picture of the most pressing issues, we conducted non-parametric comparisons (Friedman’s Rank Test with paired samples), identifying differences between the challenges on the scales ($\chi^2(4) = 103.76, p < .001$). Pairwise comparisons between the 5 previously formed scales (see Table 3; bonferroni-corrected $p$-values) found motivational and emotional issues being (significantly) more severe than any other categories with emotional issues additionally outweighing motivational issues. Cognitive and metacognitive issues on the other hand were significantly less of an issue than the other categories and cognitive issues were less relevant than metacognitive issues or managing one’s learning. However, there was no significant differences between the latter. We can thus conclude especially emotional aspects to be perceived as most challenging amongst students followed by motivational issues. Managing and metacognitively regulating the learning process were perceived as less severe but still more relevant than cognitive aspects directly related to understanding the learning content, which seems quite clearly to be perceived as least challenging by the students. The statistics for all comparisons can be viewed in Table 3.

4. Discussion

This exploratory survey study analysed the challenges HE students perceive with regard to regulating their learning during the covid-19-induced social-distance-education semester. Results indicate that students severely missed their peers and struggled to keep up their motivation and although they seemed to do quite fine cognitively, they are worried due to having so much on their hands. Thus, the most severely perceived issues related to emotional and motivational challenges while actually understanding the content with less teacher guidance and even structuring the learning process seemed to be rather less of an issue. This is in line with previous research identifying emotional and motivational challenges (e.g., Koivuniemi et al., 2017; Webster & Hadwin, 2015). While it remains unclear how exactly the pandemic-induced semester had an impact on these results and if the results are inherently due to different challenges arising from ERT or to teachers being more skilled in supporting cognition than motivation or emotion during the crises, it at least gives indications that the focus of providing students with support during this crisis should not be limited to improving the learning material to make it easier to understand the content, but that it seems important to provide support on other levels as well. Clear structures and chunking tasks may help learners to initiate their learning process and keep up their motivation while regular feedback and support and even individualised and more flexible learning arrangements may reduce stress levels. Finally, it is important to notice that altogether, students seem to be doing quite well, but seem to have trouble keeping up their concentration and motivation and especially miss their peers. The social role of the university should not be underestimated as it is not only a place to study, but a place to connect, and social support can be an important factor for academic retention and success (e.g., Wilcox, Winn, & Fyvie-Gauld, 2005).

Clearly, this initial research has some limitations that need to be discussed especially relating to the questionnaire and sample. First off, the questionnaire, while building on previously found challenges and a small pre-study, was still not validated and covered a broad range of issues. This became very clear during factor analyses which led us to discard quite a few items and the resulting scales and items still have some overlap in places. Thus, it is vital to keep in mind that this study was meant to give first indications rather than final proof. Research needs to build on this and study in more detail what learners struggle with. Additionally, the study was conducted (shortly) before students’ exams and thus the chance to compare own understanding to academic demands. Thus, perceived challenges related to understanding the coursework may be underestimating true difficulties due to a tendency of students to show overconfidence in their abilities (e.g., Ehrlinger, Mitchum, & Dweck, 2016) especially when learning is based on video lectures without opportunities for self-testing (Szpunar, Jing, & Schacter, 2014). The other aspect that needs to be discussed is the sample. The sample consisted of German university students with various majors from different universities. Thus, this sample does not reflect a homogeneous population and students may have been exposed to a large range of different courses, course structures and materials and may also have been exposed to a vast number of personal challenges during this crisis. On the other hand, the sample is still limited to German
students and may not be readily generalised towards other educational systems and / or countries in which the pandemic had a more severe impact or was met with more severe social restrictions.

It is per definition that the impact of a pandemic may affect different educational structures very differently. It is thus up to (learning) scientists to pool their data and find out more about generic but also specific educational aspects of the crisis to gain knowledge about how learners regulate their learning during this time and what we can learn from this to provide guidance or give students (and teachers) the tools to handle the situation. Thus, follow-up research needs to match the challenges learners experience to specific aspects of their educational context like course design to draw more definitive conclusions and to best support students. However, it seems clear that providing better learning material and explaining content in easy to understand terms may, while still important, not be answering to the most pressing issues which are providing means of contact between students and helping them to keep up motivation and emotional well-being.

References


Overcoming Transactional Distance when Conducting Online Classes on Programming for Business Students: A COVID-19 Experience

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Abstract: Studies have shown that transactional distance negatively impacts student learning. In the context of learning, distance pertains to the geographic, pedagogical, and psychological gap between instructors and students. This perception of distance is magnified in online learning because instructors and students do not meet face to face. The gaps involve not only the geographic aspect. Another gap is pedagogical, which depends on the online course's design and structure flexibility and how these align with the students' level of autonomy. Still, another gap is psychological, which relates to how students perceive how much the teacher is accessible or disengaged (level of dialogue) and with students' academic self-efficacy assessments. This paper describes how we could reduce the transactional distance between instructor and students by deliberately designing and conducting mostly asynchronous classes on programming for business students but with the right blend of non-lecture synchronous activities during tight lockdown due to COVID-19. We explain what used to work well before the pandemic where classes were onsite and face-to-face and what mechanisms we used to overcome the lockdown-related gaps. The course was held during Intersession and only had less than six weeks. Based on students' grades and general sentiments, the results were in line with expected learning outcomes, and miscellaneous feedback and comments from students were positive.

Keywords: asynchronous learning, online learning, blended learning, COVID-19, programming class, transactional distance, self-efficacy, scaffolding

1. Introduction

Transactional distance (Moore & Kearsley, 2011) refers to physical (especially in distance learning), pedagogical and psychological gaps, particularly between instructor and student and among students. Even in face-to-face class settings, there are pedagogical and psychological gaps between instructors and students, especially when instructors are perceived as disengaged (Clifford, 2018). This paper refers to any gaps, whether face-to-face or online, as transactional distance. Reference to the gaps is consistent with Clifford (2018), who shows that increased transactional distance and perceived instructor disinterest negatively affect student performance. Transactional distance involves three dimensions: structure, dialogue, and autonomy (Moore & Kearsley, 2011). Structure refers to the course elements such as learning objectives, content, and assessments. More structure tends to increase transactional distance because it diminishes the amount of flexibility for learners to chart their learning paths; however, less structure does not automatically mean reduced transactional distance, as will be shown later. Dialogue refers to communication between teachers and students. More dialogue tends to decrease transactional distance. Autonomy (or learner autonomy) refers to the extent that students' role in exercising self-management is that they get to decide what to learn, how to learn, and how much to learn. The level of autonomy required increases as transactional distance resulting from the given structure and dialogue increases. Since not all students will have the same level of autonomy or capacity for self-management, the right amounts of structure and dialogue need to influence the overall course design. One other thing to note is that low structure, low dialogue, and low autonomy lead to an increased transactional distance, as illustrated in Figure 1.
The school considers programming as an essential skill for business students. However, the students do not necessarily consider programming vital, especially when they graduate. Students’ focus and interest would be on more demanding and perceivably more essential subjects. Therefore, students who are required to take this course may have apprehensions, thus aggravating existing psychological gaps. They may have beliefs that they have low academic self-efficacy—judgments of one’s abilities given field with new, unpredictable, and stressful aspects (Bandura, 1977). Perceived self-efficacy is one of the largest predictors of academic performance (Eom, Wen, & Ashill, 2006; Downing, 2009; Hodges, 2008; DeTure, 2004). While on the surface, learner autonomy and academic self-efficacy seem related, there are not many studies on the relationship. Tilfarlioglu & Ciftci (2011) try to establish that relationship to academic success.

One year before the COVID-19 lockdowns, the researcher had positive results by 1) being available for consultations, and 2) relating topics to real-world applications and personal experiences. The methods and results align with discussions by Clifford (2018) on reducing transactional distance. With the COVID-19 pandemic, all interaction with students can only be through online channels, whether synchronously or asynchronously. Clifford (2018) discusses that asynchronous learning modes not accompanied by a significant interaction between instructors and students increase transactional distance. This paper describes the researcher's steps in designing and managing an online course with minimal transactional distance as a theoretical framework to maximize student learning during the pandemic.

1.2 Classroom dynamics before the pandemic

During face-to-face classes, students were free to ask questions and seek clarifications on the spot. The teacher then had opportunities to expound on the concepts on the spot. Teachers were also able to pause and ask students what they thought of certain things raised at particular moments. Students got to reflect on the answer. Students who shared their solutions got heard by others in the room. They were able to avoid misunderstanding about expectations on what had to be answered and submitted. Classmates discussed programming assignments and answers to exercises and sample tests together. They also shared possible solutions or insights to solving specific areas. This collaboration was done either in a physical setting in various places in the vicinity of the campus. This observation is consistent with the assertion that learning is a consequence of social interaction (Vygotski, 1997). As needed, students would ask for consultation hours with the teacher. During consultations, the teacher discussed thoroughly step-by-step solutions to challenging problems. For Final Projects based on real-world scenarios, student project groups also consulted with the teacher to discuss feasibility and direction. For most of the dynamics stated, there was a heavy reliance on interpersonal, face-to-face communication. Whether or not these dynamics can only be possible through face-to-face meetings or if there is an alternative way to provide most if not all benefits of collaborative learning, albeit forced by COVID-19, is what this paper will discuss.
1.3 Challenges brought about by COVID-19

The researcher notes informal conversations with a few business management majors of the John Gokongwei School of Management of the Ateneo de Manila University about their experiences with various online learning forms from the previous semester (when the COVID-19-related lockdowns started). The students cited several issues that fall under the different dimensions of transactional distance. There was a general sense of lack of structure. Some teachers dumped too much work (reading assignments, additional homework). Teachers and students had reduced communications. Students also had decreased interaction with each other. It was more challenging to ask questions and seek clarifications on various class matters. Items sent by students through email tend to take longer to answer.

In some cases, Internet access was either unavailable or unstable. There is also concern that group work cannot run smoothly. Studying with other classmates is more difficult due to the remote nature of the setup. The inability to learn together results in individuals having to take on more study load due to a lack of validation from peers on whether the concepts have been well-understood. Finally, there was a general feeling of lack of control. There was a constant fear of failing to submit requirements, especially for timed tests and assignments with tight deadlines due to poor Internet connectivity. Students also admitted not being good at time management, and the lack of structure made the feeling of lack of control worse. Studying from home was not conducive to learning as there were too many distractions. Overall, the sense of lack of control led to more stress. Distraction and confusion relate to negative academic performance (Rodrigo, Baker, & Nabos, 2010). With these concerns stated, students clamor for synchronous classes to cope with the need for structure and dialogue.

2. Course Design and Management

Transactional distance is the framework for discussing the overall course design and management for this particular online class in this study. The course design blends tutoring throughout—not just in the lecture videos and LMS text pages but also in assessments. The general course flow also relies heavily on the past experiences of students and scaffolding material. In learning, scaffolding is defined by Smith and Ragan (2004) as cognitive processing support that the instruction provides learners.

2.1 Course Structure

A module is a logical grouping of content and assessments in the LMS setup. The estimated number of learning hours per module is between 8-10 hours, and one module is approximately one week-long. The aim is to have between 45-60 learning hours (which includes watching videos, reading articles, practicing on exercises, answering assignments and tests, and working on the final project). For a programming course, this is not much time, so there had to be a way to incorporate continuous learning to spill over in areas outside of lecture and readings (content) through unconventional tricks such as embedding mini-tutorials in assessments.

The first part involving content design covers mostly the structural dimension of transactional distance. Topics span several video segments, each not exceeding 15 minutes. Cutting content into chunks is consistent with one of the strategies for the organization of content for online learners (Schutt, 2003). In place of scripts, outlines of talking points in conjunction with the desired end-state of the programming code already prepared and retyped during the video recording. The second part involves the learner autonomy dimension. Students decide how and when to take in the lessons. Program coding videos use Jupyter Notebooks for Python code, and the Atom text editor for all other text file related code illustrations (HTML and CSS). The teacher explains in the video the thought process while typing variables, statements, and function definitions. Any typing or syntax errors remain in the video to show the students how to fix things on the fly and minimize the number of questions involving syntax errors. Contextual descriptions of the videos' topics end up in Jupyter Notebooks as annotations or in the
Canvas LMS pages. While not directly addressed through content design, the dialogue dimension of transnational distance covers clarification and collaboration of the content and related activities (including assessments) through various communication channels and methods discussed in succeeding sections.

The course uses four (4) types of assessments: 1) Assignments (similar to a take-home quiz), 2) End-of-Module Tests (covering 1-2 weeks or modules worth of content and are answered individually), 3) Major Tests (which look like mini-projects and are group work), and 4) A Final Project or Capstone. Assignments are intentionally more challenging than the End-of-Module and Major Tests. The thinking behind this is that assessments need to build on top of what the students already know. Having challenging assignments and exercises will prepare students to perform better in the tests. The first few assignments are simple, and it is easy to get a perfect score. The difficulty progresses throughout the course, and assignments coming in later have more real-world use cases. An example assignment which resembles a mini-project with medium complexity is Coffee Python, a prototype Point of Sale (POS) system in Python. End-of-Module Tests cover material for the previous module. These tests’ completion times are intentionally short but fairly reasonable (between three to 24 hours). The intent is for each of these tests to be answerable within three to five hours, but the 24-hour window gives the student fewer chances to cite lack of time as a reason for not doing well. Major tests are more like mini-projects and are summative. They also are group work. Each group had 96 hours or four (4) days to complete the test. The tests also had embedded mini-tutorials (which also act like scaffolds) to teach students concepts not learned in any videos or pages. The embedding of scaffolding as mini-tutorials is consistent with the practices described in the work of Feng & Koedinger (2009).

2.2 Limitations, Technology Platforms, and New Capabilities

The primary Learning Management System (LMS) used for the course was the cloud-based Canvas Free for Teacher Use. The Canvas course pages have private, unlisted YouTube videos embedded together with supplementary text. Recording the videos with multiple video and audio sources was possible using Open Broadcast Software (OBS). The video sources were browser windows containing Jupyter Notebooks and screen projections from the iPad. Jupyter Notebooks was the primary programming environment due to the ability to add rich-text notes in the Markdown language before each program execution cell. On occasion, text editors were used, with the Atom text editor as the course’s prescribed choice. Whatever dynamics present in face-to-face classes lost with the pandemic lockdown translate into new modes of interaction. Not everything about the previous onsite class setup was ideal, in any case. COVID-19 hastened decisions to try different modes of learning. With structure, students can go through the course regardless of where they are, and they do not need to be within the vicinity of the school. Location independence benefits students from the provinces who could not go back within the university’s vicinity. Students also have more leeway to submit assignments at their own pace. This flexibility also eliminates one source of stress, consistent with benefits cited by Clifford (2018). With the level of dialogue, the aim is for more in-depth discussion topics beyond the core concepts. Recorded video lectures allow students to replay portions they need to study until they understand the material, thus reducing the need for consultations with the teacher.

The live-coding style of videos looks more natural than merely showing pre-built code in presentation slides. The researcher uses social media channels for timely feedback and more substantial social and personal impact to be consistent with the assertion that learning is social (Vygotsky, 1997). Using Facebook effectively in education is consistent with Eger (2015) and Dougherty & Andercheck (2014). Discussion forums and group chats take the place of asking questions or sharing thoughts in-class. Announcements through LMS with backup reminders through FB Groups replace in-class or email announcements. Group chats enable collaborations that otherwise were only possible through meetups in physical places in and out of the campus. Consultations with the teacher on lessons or projects are possible through Google Meet or Zoom, with trivial questions and consultations quickly done through chat or email, unlike in the previous setup where students could only arrange for appointments for face-to-face meetings outside of class hours. Last, with learning autonomy, the
provision of Jupyter Notebooks produced from the video lecture recordings can be played around by the students.

2.3 Student Participants and Data Collection Methods

The class under study involved 28 students from the Bachelor of Science in Management Engineering Program from the John Gokongwei School of Management of the Ateneo de Manila University in the Philippines. The students had varying degrees of background in programming ranging from no experience to having taken courses but have forgotten the material since their Senior High School days. The study works with a sample representing the whole batch of BS Management Engineering Students at the Ateneo de Manila University as the population. The class formation cannot pass as random because students had a choice on which classes to join. Besides, unlike all other business management students, Management Engineering students have been qualified to join the program based on math aptitude.

Questions and comments on the topics, assignments, and assessments smoothly went through FB Messenger, Email, and the Canvas LMS Messaging facility. Grades recorded in Canvas LMS provide data on student course performance. Students frequently answered informal surveys that checked their pulse and sentiments through Facebook Messenger and Facebook Groups. Assessment scores and final grades are available through the LMS. One limitation of the study is that since everyone had to rush from face-to-face to online classes, there was very little time to plan for more rigorous data gathering techniques.

3. Results

Performance across the board at the end of the class was positive. Final grades were computed, with 24 out of 28 students getting A and 4 out of 28 getting B+. The complexity of the final projects was unexpected. Students were also able to do additional research on topics not covered in any of the lessons, and they were able to use the new knowledge in all final project submissions. None of the students were considered mediocre, and no one was ever in danger of failing the class.

Informal feedback from students was mostly positive as well. The feedback items can fall under the relevant transactional distance dimensions of structure, dialogue, and learner autonomy. In providing ample structure, the students enjoyed the sample code, which acted as scaffolding and mini-tutorials in assignments and the other assessments. These, together with relaxed deadlines, also made performing the assessments and overall learning experience more fun and less stressful despite the assessments being challenging. In addressing the perceived need for more dialogue, students found the ability to repeat videos, especially discussions on difficult examples. Even without actual conversations with the teacher, the videos flowed naturally (showed errors, discussed tips on finding patterns and building blocks), and covered many aspects of programming. Thus, repeating the videos minimized the clamor for consultations and synchronous classes.

Contrary to the general clamor to have more synchronous classes, the students of this class stated that there was no need for these since the teacher had been accessible through Messenger, and, at times, through Zoom for consultations. The students also agreed with the decision to allow the use of Facebook Groups and Messenger and they found the conversations and consultations valuable, especially during times when they felt stuck with specific concepts. The number of communication platforms was not an issue. Students realized they love programming because they saw their work fitting in broader real-world application settings. To promote learner autonomy, Relaxing deadlines for assignments made the learning experience more relaxed and fun, even if the teacher gives the most challenging problems. The scaffolds made it easier for students to research outside of class and encouraged exploration. Video lectures showing the teacher making mistakes (not edited out) encouraged students to try other scenarios to commit and fix errors.
4. Discussions

The outcomes of the implementation described in this paper are consistent with findings from previous work. The outcomes cut across the three dimensions related to transactional distance (Moore & Kearsley, 2011). All-in-all, the decision to address transactional distance are:

Ample structure, by providing scaffolding with ample flexibility throughout the course, record videos showing mistakes and correcting on the spot; More dialogue, by making the instructor available through chat and email and, occasionally through Zoom meetings, for consultations involving exercises, assessment tests, and the final project; and Ample learning autonomy by making deadlines less strict and making videos digestible enough to repeat repeatedly.

The combination of design choices for this online course made transactional distance negligible despite the lockdown-induced remote learning setup, as shown in the quality and complexity of final project outputs and the individual grades. More work, however, needs to be done, especially on the data gathering aspects. The next iteration of the course will include improvements based on the outcomes of this first run of the blended learning course.

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References

Connecting Teachers during a Global Crisis: A Knowledge Building Professional Development Approach to Embracing the New Normal

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Abstract: A global crisis such as the COVID-19 pandemic has disrupted almost every industry and the field of education is also affected with safe distancing measures and minimal face-to-face interactions between teachers, students, and their families. However, new opportunities and technologies have emerged for teachers to utilize and work with students and their parents. We investigated a case study of a community of pre-school teachers who continued their professional discussions on a virtual and asynchronous discussion platform throughout the lockdown period caused by COVID-19. The teacher community planned for and conducted lessons using the knowledge building approach. This paper reports the considerations and implementation of a community-based professional effort through times of immense disruptions and have shown evidence that the knowledge building approach can propel a community of learners to construct collective inquiries and solutions to deal with emerging problems through the lockdown period. The knowledge building approach can potentially enculturate teachers towards noticing new and emergent ideas in their classes and thereby elevating the awareness of teachers to design and build new knowledge of their practice. Such teachers' professional culture is conducive for tackling the constant change and disruption in the educational landscape, such as the one brought about by the COVID-19 pandemic.

Keywords: Knowledge building, Knowledge Forum, new normal, COVID-19

1. Introduction

A localized crisis tends to affect a geographic region, requiring quick thinking and adaptability by impacted stakeholders to react with actions that might not be persistent in the long term. Conversely, during a global and modern crisis such as the COVID-19 pandemic, almost every industry and country are affected, along with their goals and profound implications on its relationships with its stakeholders (Bundy, Pfarrer, Short, & Coombs, 2017). Teachers and students are affected by school closures reported in an estimated 188 countries, affecting more than 90% of enrolled learners worldwide (UNESCO, 2020). Such global crises are unexpected and rare in nature, as such needing quick assessment and responses from educators that can lead to "erroneous inferences and resistance to learning" (Lampel et al., 2009, p. 840). For example, on the one hand, when faced with the need to switch to completely online interaction with their children with a short turn-around time, teachers may revert to practices that are easy to implement, e.g. students watching videos or completing online worksheets, but ones that lack in-depth thinking and creativity (Veil, 2011). On the other hand, technological advancements have afforded appropriate teaching pedagogies and approaches for teachers to embrace the new normal to design meaningful interactions with their students.

In this paper, we investigate a case study of pre-school teachers who planned and conducted a series of lessons, based on the knowledge building approach (Scardamalia & Bereiter, 2006) that was introduced to the teachers about four months before the Home-Based Learning (HBL) sessions and continued on a voluntary basis throughout the COVID-19 lockdown period. We report the teachers' adoption of this approach and the guiding principles, along with how the teacher community engaged and connected virtually in place of minimal face-to-face contact. The impact of this knowledge building
approach on the teachers becomes part of a new normal, in which we believe will aid and potentially replace some existent ways of teaching and learning for pre-school students.

2. Participants, settings, and equipment

2.1 Participants

A total of six pre-school teachers were involved in this study and the teachers' first engagement with knowledge building was in December 2019. The teachers, also known as early childhood educators, were trained and certified in early childhood education and care. The teachers were new to the knowledge building approach. Weekly school-based discussion (one-hour each) was held as an ongoing professional development programme. There was a change of two teachers during the study but due to proper handover and the teachers working together as a community, there was minimal impact on our findings.

2.2 Settings

The pre-school is based in Singapore and the curriculum of the pre-school is wide-ranging, designed by the Ministry of Education (MOE) to guide the work of early childhood practitioners. The teachers chose to integrate knowledge building into the Discovery-of-the-World (DoW) component, one of six key learning areas proposed by the "Nurturing Early Learners" (NEL) framework (Bautista, Ng, Múñez, & Bull, 2016). This DoW component poses three goals: children should (1) show an interest in the world they live in, (2) find out why things happen and how things work through simple investigations, and (3) develop a positive attitude towards the world around them. Two topics from this component were chosen for discussion, namely, "The Amazing Human Body" for 5-year-old students and "Science in Everyday Life" for the 4-year-old students.

We engaged the pre-school teachers before the COVID-19 pandemic set in at the beginning of the year 2020. Singapore underwent a "Circuit-Breaker" period that was similar to a lockdown from April to June 2020, where teachers have to work from home and students were to engage in HBL. Essentially, former practices and face-to-face lessons that were critical for engaging students were no longer viable and teachers have to look at alternative online technologies to aid teaching and continue connecting with students and other teachers. Contingencies planned before the lockdown were mostly designed to be short-term ranging from days to weeks and therefore new plans have to be designed and implemented for an extended period in terms of months and also in a sustainable manner.

2.3 Equipment and schedule

The teachers possess basic computer literacy, but these literacies varied according to their personal experiences with digital technologies and not specific professional development on ICT related to this study. The teachers meet weekly and used their own mobile phones or school-distributed computers to access meetings held on Zoom. Access to the internet at the pre-school was prevalent, which allowed the teachers to be able to access online conferencing and Knowledge Forum (KF; Scardamalia, 2004), an asynchronous online discussion platform for supporting knowledge building. Teachers involved in the Knowledge Forum are provided with a space for discussion with options to spatially reflect their practices, recognize and build on each other's ideas, while using scaffolds to aid each other in the sharing and rise above of ideas.

3. The process of embracing a new normal

Although there was an urgent need to address the myriad of administrative and operational issues that emerged during the period, it was noted that there were three phases that the community of teachers
generally underwent in embracing the new normal. The three phrases are (1) getting the ball rolling, (2) persistent efforts in reaching out and connecting with students’ parents, and (3) connecting discussions during HBL to discussions held when students returned to school. We illustrate the manifestation of these phases in the following segments and discuss the value and challenges of such teachers’ knowledge building work during the lockdown period.

3.1 Getting the ball rolling

For a start, two pages, also known as KF views, were created and hosted in a virtual space on the Knowledge Forum for the respective topics of "The Amazing Human Body" (see Figure 1) and "Science in Everyday Life". KF views are conceptual spaces to hold discussion notes relating to certain topics. Sub-topics and the connections from each topic were mapped and placed as background on the KF view. Teachers post their lesson ideas, new resources, students’ artefacts, and updates from their lessons asynchronously. They also reflected on the knowledge building theories; how they understand the theories; and how they see the theories manifested in their class (Scardamalia, 2002). The six teachers then met weekly to discuss what they posted about knowledge building principles and their lesson progress. They also use this time to analyse students’ drawing and students’ responses during the small group of whole-class discussion. This weekly meetup started three months before the lockdown and persisted throughout the lockdown period when all schools were told to switch to HBL.

Figure 1. A screenshot of the teachers’ knowledge building view and two sample notes (expanded) that explored activities, ideas, and principles on "Our Amazing Body System".
The pre-school teachers decided to continue with the weekly meeting via Zoom. The Knowledge Forum notes became the object of discussion at each synchronous zoom meeting. Figure 1 shows a screenshot of the teachers’ knowledge building view that reflects a mixture of lesson ideas and resources (e.g., "Why the body needs both muscles and bones?" and "Bones"). Teachers also described their enacted lessons in the note (e.g., "Test of effectiveness of facemask"), their initial and evolving ideas ("How students' ideas overlap with these interests?"), and their reflections on discussions on knowledge building principles (found in another KF view).

There were indications of individual and collective knowledge-building as teachers navigated the online and offline discussion on knowledge building classroom. One of the teachers (Teacher 1) posting an interesting note (see Figure 2) using scaffolds that appear in angle brackets (e.g., <scaffold>). This teacher had an idea of how to teach the concept of bones to students, based on her prior experience on the topic, but shared at the meeting that she initially did not view the ideas in a broad or "big-idea" manner.

**Figure 2.** A Knowledge Forum note titled "Bones" posted by Teacher 1, suggesting how the concept of bones can be taught to the students, relating to the big ideas.

Teacher 1 later elaborated on her note (Figure 2) through an online synchronous meeting, commenting that she would want the students to examine the shapes of chicken bones and find the connections so that students may relate this information with the human body structure and how bones may help to protect human organs. The following are parts of the teacher community transcript between the teachers and one of the researchers, who was also an active participant, detailing the teacher's elaboration.

**Teacher 1:** Previously... ...I allow children to examine chicken bones, different sizes and shapes of bones, also for them to look at how the bones are connected... ...to relate, somehow relate it back to our own body system, bones. So, this is one activity that I done it before, so I just share it. So, I thought it'll be good for children to observe bones and how they can protect the organs and stuff like that- yeah.

**Researcher:** Ok, so what will be the things that will be covered when they do this activity. What are the ideas you hope to...?

**Teacher 1:** So how they can link... ...understand how these bones come together to form different shapes so kind of correlated to what our body is and how these bones are formed to protect certain organs like the ribs and stuff like that. So, this is kind of a way to get them to relate to our body. Yeah, because it's easier for us to get chicken bones rather than you know the other kind of bones (laugh) so I thought this is one way...

Continuing from her elaboration, Teacher 1 was further questioned on what kinds of preparations she had in mind for the upcoming lesson.
**Researcher:** Let's say we have to do this activity. What kind of knowledge building talk would you design or facilitate? ... ...Like you were saying maybe we can get students to talk about, have some questions, because they are touching and feeling it. So, what kind of knowledge building talk, I wonder what is like the starting question of the knowledge building talk? Any thoughts?...

**Teacher 1:** I think it will be good if you start off with a, maybe a book storytelling on bones. Something like that and after that get them to share their thoughts, after reading the book and then this can be the main lesson or the next lesson to, kind of, like get them to connect, you know. So, I think can start off with book or video or something like that to get them to observe and then they learn from it from that particular topic and then this could be the next lesson.

**Teacher 2:** So maybe we can start off by saying you know, we are going to talk about your body. Who can tell me what's in your body? So, let them name all the different things in their body; skin, bone, organs whatever. And then from there, can we dive deeper into the different areas. You know like what do you think bones is [are] for? How is [are] bones helping you and all that kind of things and also talk about like um- um- what makes strong bones so from there can you know expand a little bit more about the body and then in particular the different structures of the body.

**Researcher 1:** So Teacher 1 is [and] Teacher 2 is [are] making us think like, which part of the lesson I'm going to do this activity, [and] will very much determine on what I am going to do in the knowledge building talk and then Teacher 1 and Teacher 2 are saying that maybe there needs to be something else before this activity to get them [students] interested.

Teacher 1 eventually realized the need to consider some "big ideas" apart from the initial foray in using the related scaffold in her first note, but the notion of 'big ideas' is still vague. The researcher then asked the other teachers in the Zoom meeting to elaborate more on any attempts at investigating big ideas. Another teacher (Teacher 2) started explaining her method of involving students to think about big ideas, using an experiment on the topic of digestive systems.

**Researcher:** ...We have a note on [the] experiment [that you did]... ...do you want to talk about it? Uh yeah, experiment on digestive system.

**Teacher 3:** So for me, I thought that this should be a follow-up lesson because once we introduce the students the digestive system, the overall picture and idea of it, I think they will be more likely to understand if you show them an experiment on how the different parts, erm, the process of the digestive system, so this activity is actually an experiment that I saw on YouTube. So yeah, it will actually show a brief process of how the digestive system works like how they will use crackers and bananas and smash it together and then they will cut holes and squeeze through a stocking to show the process of how the large intestines work, yeah.

**Researcher:** And say a little bit about how you put up the big question, the big ideas. I actually quite like it.

**Teacher 3:** So, I was just thinking how children would be more likely to link the topic into the digestive system itself. So usually we talk about food and going to the toilet and so I wanted to relate it to them. Such as, with questions like 'Why do we need to eat and drink first? Then, if you ever had stomachache, how did you feel or what usually causes the stomachache? So, from there, it will lead into it being in the digestive system and
probably the food that they intake or not being able to digest... ...if they eat too much of candies.

The note in Figure 2 was actually picked up through Knowledge Forum by Teacher 2, who considered the idea and built on it with an elaboration of an experiment related to the human digestive system that she was considering conducting. She then listed several YouTube videos and "big ideas" that she intended to introduce to students. These big ideas were part of a concept in knowledge building that students were investigating, allowing them to raise questions and pursue the answers in a collaborative manner. In doing so, the learning process becomes self-actualized and appreciated. We see a deliberate consideration for 'big ideas' in subsequent discussions and lesson designs. Examples of such big ideas that will frame her activities in class are as follow:

1. Why do we need to eat and drink?
2. How does food move through our bodies?
3. What do our bodies get from the food we eat?

Teacher 3 reflected on the knowledge building principles as the basis of her teaching moves and decisions:

Researcher: Nice, nice. And you also picked idea diversity [knowledge building principle], could you just share why you picked this...

Teacher 3: I went to, I went to read about diversity, and it talks along the lines of how children will be able to explore and understand the topic. Something about understanding the idea around that topic, so like what I mentioned, digestive system is very advanced and is pretty complex with all the different organs and the different process that takes place in one system itself. So, that's why I classified it under idea diversity, so that through this experiment, at least they would be able to understand the process and the idea around it.

Teachers took comfort in knowing that other teachers were also thinking along the same lines for planning and teaching of online lessons using diverse ideas to initiate discussions on various topics. In such a blended professional discussion, teachers have more time to read through each other's notes on the Knowledge Forum, they could build on and share queries and ideas on the Knowledge Forum before considering the sequencing of the lessons. In the subsequent teachers' meetings, there was a greater sense of idea-sharing and idea-building among the teachers on the two mentioned topics and teachers were able to work together and to review lesson progress in a meaningful and effective manner, supported by the Zoom platform and Knowledge Forum.

3.2 Persistent efforts in reaching out and connecting with students’ parents

In the weeks that followed during the lockdown, the teacher community further explored the idea of home-based-learning. One teacher pointed out that the viral infections (COVID-19) could be a very good trigger to kick-start the discussions following students’ interests and inquiries on breathing and lungs. There were discussions on whether parents could be involved in students’ learning outside of classes since the teachers were already conducting home-based learning with the students. This idea prompted the teachers to deliberately involve parents in their subsequent knowledge building lessons. This process of getting parents to be involved in learning consequently brought greater awareness to parents of what students were working on with their teachers. Considering the enforced circumstances that the lockdown has imposed on the pre-school community, the teachers and the school leaders were able to adapt to dynamic and changing conditions, even thinking out of the norm with considerations of using authentic situations to trigger thinking and involving parents in activities that otherwise would be impossible to conduct on pre-pandemic situations.
Midway through the lockdown, the group of teachers continued to explore ways to involve parents and they collectively agreed to share a copy of the knowledge building scaffolds. They hope to encourage parents to engage their children in knowledge building at home. Parents were requested to work with students on a document that was embedded into the Knowledge Forum. This home-based learning activity on “The Amazing Human Body” got parents to work with and document how students could use reusable materials such as straws and plastic bags to create a model of the human lungs. A consistent communication channel was also set up between the teacher community and the groups of parents and students to discuss about their prototype lung model.

3.3 Connecting discussions during HBL to discussions held when students returned to school

Singapore exited the lockdown in June 2020 to a phased resumption of daily activities, including allowing pre-school students returning to the classrooms to resume their education. The teacher community then consolidated the online discourse on Knowledge Forum and printed the online mind map that captured the students’ ideas and questions onto a large physical poster (see Figure 3) that was displayed in the pre-school, so that students on returning to the school could relate to the activities that were conducted during the lockdown. Returning students were quick to identify and point out the questions that were raised during the home-based learning activities and were able to continue knowledge building with the teacher community in the physical classroom.

Among the lessons that were brought up, a prominent example was about how knowledge building was used as an approach for 6-year old students to start a discussion related to the pandemic, such as identifying the job scopes of frontline and essential workers. Overall, it was a gratifying experience for all stakeholders and there will be ample opportunities for knowledge building to continue during school lessons, home-based learning, and when working with parents in homes.

![Figure 3. The online discourse from the Knowledge Forum was consolidated into a physical poster and displayed on the wall of the pre-school for students’ reference.](image)

4. Conclusion

The COVID-19 pandemic and social-distancing measures that were put into place may have created physical distance and minimal face-to-face interactions between teachers, students, and their families.
The knowledge building theory has helped to forge a greater sense of communal belonging among teachers and also helped to assemble a community of learners who constructed collective inquiries and solutions for authentic problems and responded to emerging situation and needs. The onset of the pandemic may well have elevated teachers and students’ awareness of the need to use knowledge building as a promising foundation for a responsive and progressive approach to teaching and learning. This study has provided evidence that even through trying times, teachers and students in schools are reinvigorated and stimulated to continue striving towards a new normal that involves greater integration of technology for interaction and collaboration in schools. Knowledge building has also provided the opportunity for newer perspectives of classroom practice and teacher professional development that supports the deviation from a common norm of working with students and their parents.

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**References**


Synchronous Online Lectures in Emergency Remote Teaching: The Role of Immersion, Social Scripts and Group Awareness

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Abstract: Switching to synchronous online lectures during the Covid-19 pandemic poses many challenges for teachers. On-site and online lectures are different in ways that may add new challenges for teachers and students and thus affect teaching quality. While there is a substantial amount of research on conducting online courses and fostering online communication and interaction, the specifics of lectures and the challenges imposed by the emergency shift to an online format are still understudied. Thus, in this contribution, we discuss three core aspects that need re-investigation when switching to an online format: the teaching context, the availability of social information and the social requirements of the learning scenario. The Learning Sciences are equipped to answer to such challenges by providing evidence-based information on requirements and (technological) support for social interaction processes within education.

Keywords: Synchronous Online Lectures, Immersion, Script Theory, Group Awareness

1. Emergency Shift to Synchronous Online Lectures

The Covid-19 pandemic forced many countries to impose social-distancing rules. As a result, educational institutions like universities had to drastically adjust their teaching structures and switched to emergency remote teaching (ERT), “a temporary shift of instructional delivery to an alternate mode due to crisis circumstances” (Reynolds & Chu, 2020, p. 233). A first goal was to provide emergency instruction and learning opportunities, but, as the crisis continues, teaching needs to exceed “emergency care”. While education may not need to be restructured for good, challenges need to be faced to support teachers in providing high quality learning opportunities for students during the crisis and beyond.

In higher education, lectures are a central form of teaching. While they are traditionally teacher-centred and have been seen as rather passivating students in the past, they now integrate various resources, dialogue tools and interaction processes and are still one of the most frequently used forms of higher education teaching (Crook & Schofield, 2017). However, successful implementation of lectures depends on various factors, as they are a social situation that requires adequate social interaction between teachers and students. For students to benefit from lectures, teachers have to engage them and need to tailor their instruction to the students’ needs. For teachers to know which behaviour is required of them, they require awareness of the social context and thus of their students. Although various forms of online teaching are available, many teachers may choose synchronous online lectures especially for large classes instead of more unfamiliar, less commonly used formats (e.g., flipped classrooms).

The ad-hoc shift to synchronous online lectures may affect various aspects impacting teaching quality. In the current paper, we focus on how teachers can be supported in this shift, so that they have the necessary tools to give and improve online lectures. One major distinction between virtual and on-site lectures is the physical distance between teachers and students, affecting the teaching context, perception of the social context, communication channels and modes of interaction. Teachers’ awareness and thus their ability to choose the correct behaviour may be restricted during online lecturing. In the following, we describe three challenges arising from these changes and their impact on
teaching processes. Then, we provide examples of how the Learning Sciences are equipped to provide solutions and may even use this momentum to go beyond the possibilities of traditional on-site lectures.

2. Challenges in Synchronous Online Lectures

Altogether, teachers are facing various challenges while switching from on-site to synchronous online lectures. Three challenges in particular relate to the specific changes emerging from the need to stay physically distant. Teachers’ awareness of the situation and their students is restricted by (1) the change in the physical and social context in which teachers are carrying out teaching activities, and (2) the reduction of channels through which social information about students can be transmitted to teachers. Hence, (3) a necessity arises for teachers to adapt internal scripts developed for on-site lecturing to the new situation of online lecturing. In the following, we will describe those challenges in more detail.

2.1 Teaching Context

While in on-site lectures teachers are situated in a context that is habitually connected to education and thus to the activity of teaching (e.g., a lecture hall), this is not the case for synchronous online lectures. The environment when teaching from home or even the office is not primarily associated with teaching. The communication technologies they use to be connected with their students try to replicate face-to-face lectures in a virtual environment (e.g., video conference software), but their physical environment does not match the teaching situation. This shows a clear mismatch between the physical context when teaching from home or the office and the computer-mediated teaching activities. Further, knowledge acquired in a physical environment connected to education may be situated and transferring it to another (non-educational) environment may be difficult for teachers (see Gruber, Law, Mandl, & Renkl, 1995). Additionally, the unusual physical context in this environment may lead to an uncertainty concerning expected behaviour, and also involve challenges due to the environment itself (e.g., distractions or unfamiliar behaviours like sitting during lecturing). In addition to this gap between teachers’ physical context and their activity in the virtual computer environment, experiencing the social context in virtual lectures differs from face-to-face lectures. Social presence, the “sense of being with another” (Biocca, Harms, & Burgoon, 2003, p. 456), is influenced by representations of other humans in technological interfaces. From teacher and learner perspectives, lectures that are situated in an online setting can result in less classroom awareness and social presence than on-site lectures (Olsen, Faucon, & Dillenbourg, 2020). The social information that can be provided in an online lecture setting (e.g., black rectangles representing learners) may diminish teachers’ sense of talking to real people and lead to a feeling of disconnectedness with their students. Establishing eye-contact with students to form a psychological connection and reduce distance, for example, is not possible with usual video conference systems. It is thus clear that both the physical and social context in which teachers operate when teaching from home differ from their usual context when lecturing in a co-located setting.

2.2 Availability of Social Information

Lecturing is basically a form of one-to-many communication. Successful communication requires the communicator to adapt their utterances to the recipient(s) to foster their understanding of the message content (audience design; Clark & Murphy, 1982). This requires awareness about the recipients’ knowledge and expertise, but also current understanding and attention. Group awareness is an individual’s salient perception of relevant information about the group or group members like their location, activities, cognitions or feelings (Bodemer & Dehler, 2011). In on-site lectures, teachers have a variety of auditive and visual information available that may give indications about the students’ level of understanding, confusion or concentration, thus fostering group awareness. For example, head gestures like nodding, or facial expressions like raising or furrowing of brows, but also acoustic signals like rising background noise may tell a lot about the students’ current mental state. In virtual lectures – while not completely absent – especially non-verbal feedback channels are severely restricted and mostly downscaled to fit a small screen. Without adequate information available, especially
inexperienced teachers may overestimate the similarity between their own level of understanding and capacity to understand the material and their students’ by using their own knowledge as a default (Nickerson, 1999), thereby overestimating their students’ ability to grasp complex concepts. Such biases may lead to inadequate instructional communication affecting the quality of teacher-student interaction. Research has repeatedly shown that tailoring explanations to learners’ needs is important for facilitating student learning but requires teachers to access relevant information about the students (e.g., Wittwer, Nückles, & Renkl, 2010). The restricted communication channels in remote teaching hamper such efforts by making it harder to provide and receive non-verbal feedback. This may not only unsettle teachers, but may severely hamper the quality of lectures because adaptation to students’ needs is the key to student-centred teaching and sets online-lectures apart from providing videotaped material.

2.3 Activation of a Social Script

What is happening between teacher and students during a lecture can be understood as a social process for which well aligned social scripts (i.e., cognitive schemas) needs to be activated in both teachers and students. The social script enables teachers and students to act reasonably in a reciprocal way and understand the actions of the respective others (Fischer, Kollar, Stegmann, & Wecker, 2013; Schank, 1999). Social scripts include knowledge about the roles teachers and students play in specific social situations and the sequence of activities carried out by individuals with different roles (Kollar, Fischer, & Hesse, 2006). Understanding the lecture as social learning scenario, teacher and students need to share an understanding of the sequence of activities, such as explaining, listening, providing feedback, and processing feedback reciprocally. However, different problems can emerge with the activation of the social script when the context of the lecture changes as it is the case for emergency online lectures. For both teachers and students, not being in the usual physical environment for lectures (e.g., lecture hall) might increase the likelihood for the activation of different social scripts than usually activated in lectures. Being in solitude, students might rather activate individual learning scripts not including social interactions such as asking questions for clarification. The same way, teachers might not activate their commonly activated social scripts for lectures, leading to being less open to students’ request or rare attempts to communicate. The situation gets even worse when the social scripts activated by teachers and students do not fit together. If only one of them has activated a script that includes almost no interaction and will behave accordingly, even if teachers might try to apply a more interactive script, learning-beneficial mutual activities will fail (Kollar, Fischer, & Slotta, 2007). Another problem appears when students and teachers have the same social script activated, including interaction, but fail to provide and/or receive the awareness information necessary to enact the social script properly.

3. Supporting Synchronous Online Lectures

Psychologically informed technology and pedagogy may be used in a variety of ways to meet the challenges described above. Teachers’ awareness of the social context can be supported so that it is more similar to or even better than in on-site lectures (1 and 2) and teachers can be supported in developing or adapting adequate lecture scripts suitable for online teaching (3). Research on immersive technology and social interaction (e.g., in CSCL) has developed various approaches to meet difficulties related to computer-supported social interaction processes. In the following, we will present examples of how this research may help with mastering the three described challenges.

3.1 Immersive Technology to Blend Contexts

Through the switch from an on-site lecture to an online lecture, the context changes for teachers. Their physical environment and their lecturing activities through a virtual platform do not match anymore. A solution for this may be to provide teachers with a virtual platform they can be fully psychologically immersed in, so that their physical environment fades into the background and the mismatch becomes less salient. Technologies that can deliver immersive experiences like virtual or augmented reality are
becoming more common in educational settings. Classrooms or even whole campuses can be replicated in virtual worlds where students and teachers can walk around as virtual avatars. Even without using fully immersive technologies like VR headsets and only desktop-based application to view a virtual, replicated lecture hall, a psychological immersion is possible (Robertson, Czerwinski, & van Dantzich, 1997). The additional mismatch between the representation of the social context in a virtual lecture setting and a lecture hall full of students may also be overcome using immersive virtual environments. In such an environment, the representation of students as individual avatars occupying individual seats within a virtual lecture may foster social presence to an extent comparable to an on-site lecture. Non-verbal signals conveyed through avatars can have an influence on the sense of social presence and interaction regulation in groups (Allmendinger, 2010) and this may also be transferable to teachers in online lecture settings. It needs to be examined how exactly the situational and social immersion of teachers into virtual lecture halls can be supported and how it can be used to support home-based teaching activities. As research in the Learning Sciences takes place at the intersection of psychology and technology in educational settings, it is equipped to bring insights for these questions.

3.2 Awareness Tools to Provide Social Information

The lack of group awareness and their support in interpersonal learning scenarios has been widely studied in computer-supported collaborative learning and work research (see Bodemer, Janssen, & Schnaubert, 2018). While it may seem reasonable to use immersive technology to re-build classroom-like virtual realities that merely mirror students’ behaviour, by providing information that is not readily observable, tools to foster group awareness (i.e., group awareness tools) may even advance awareness beyond face-to-face settings (Buder, 2011). While mostly applied to equitable learning settings in which peers learn collaboratively, the tools developed may also be used to inform teachers and thus serve a function similar to teacher dashboards. However, designing group awareness tools is by no means a straightforward task and requires deliberate decisions about data selection, collection, transformation and presentation (Schnaubert, Harbarth, & Bodemer, 2020), each depending on the function and scenario of tool implementation. Thus, the key questions for including awareness tools into live lectures to support teachers are: (1) What information is most relevant for teachers when they conduct online lectures? (2) How can relevant live information about students be collected without interfering with their learning processes and protecting their privacy? (3) How does the data need to be transformed (e.g., simplified) to provide useful information to the teacher? And finally, (4) how can the data best be provided to the teacher without requiring much attention during lecturing? Learning Scientists are predestined to answer those questions as they concern psychological, educational and technological input and may not be solved by one discipline alone. For example with regard to data collection, face recognition software may be used to infer mental states from detecting facial expressions and tracking head gestures in real time (e.g., el Kaliouby & Robinson, 2005). Such information, pre-processed, aggregated and fed into an awareness tool, may provide a more complete picture than a glance into a full lecture hall and thus may even outperform information available in on-site lectures. While it is pertinent that the presentation of the information does not unnecessarily distract the teacher from the primary task of teaching, ambient displays, for example, are specifically designed to require minimal user attention (Mankoff et al., 2003) and thus information may be presented by unobtrusive means like illumination (e.g., Alavi & Dillenbourg, 2012).

3.3 External Scripts to Support Appropriate Script Activation

As internal social scripts are highly flexible, teachers and students have the ability to adapt in a way that makes the new situation with online lectures beneficial for learning. However, this adaptation does not always happen automatically, either because teachers and students might not be aware of the problems or what needs to be changed or because they lack knowledge about how to change their activities to overcome the obvious problems (Fischer et al., 2013). The problem with activation of inappropriate social scripts can be tackled by providing external scripts. These have been successfully applied to guide students through social learning scenarios (Vogel, Wecker, Kollar, & Fischer,
Computer-supported or computer-mediated learning environments are particularly suitable for providing collaboration scripts. By just-in-time prompting, information about the sequence of learning beneficial activities and the social feedback required from teachers and students can be offered to both teachers and students (Radkowitsch, Vogel, & Fischer, 2020). These external scripts could either be designed by the teachers themselves to guide students through the activities needed in their pedagogical approach. But also, learning sciences approaches can be used to design more or less generic external scripts that can be used by both teachers and students. In recent times, the development of technology opened possibilities to integrate intelligent support to adapt external scripts to students’ needs (Rummel, Walker, & Aleven, 2016). While research on external script so far has mostly focused student learning, the current situation taught us that shifting the focus on both students’ and teachers’ development of social scripts for different contexts of teaching and learning is a timely necessity.

4. The Role of the Learning Sciences in ERT and Beyond

This paper outlines challenges of online lectures during ERT and identifies three major challenges for teachers relating to (1) changes in the teaching context: lack of immersion and mismatch between context and activities, (2) changes in the availability of social information: lack of group awareness, and (3) changes in behavioural requirements: adaptation of internal lecture scripts. Additionally, based on immersion, group awareness and script research, it sketches possible ways to overcome these challenges. In this situation, teachers need institutional support informed by evidence-based research. It is a task for the Learning Sciences to not only provide such information but envision ways to go beyond the needs of the current situation and design sustainable learning and teaching environments adaptable to on-site and off-site teaching and learning alike based on interdisciplinary research. While online lectures are only one way of teaching large classes online, lectures are still one of most common teaching formats in higher education. It is thus important to support teachers in this form of online teaching. Furthermore, online lectures do not only bring new challenges but also new potentials. Immersive technologies offer the potential to integrate group awareness information into an immersive virtual environment by showing relevant non-verbal behaviour but also additional information about students’ (cognitive and motivational) states not readily observable in face-to-face lectures. Automatically collected information (e.g., facial expressions, gestures) could be displayed directly as part of the students’ avatars or collated to provide teachers with easy-to-process information on the whole course requiring minimal attention (e.g., via an ambient awareness tool like “Lantern”; Alavi & Dillenbourg, 2012). Also, students could supply information themselves and online lectures could be enriched by adding interactive activities, which can provide instructors with awareness information and also engage and activate students (Olsen, Faucon & Dillenbourg, 2020). Taking a sustainability perspective, developing such tools to support synchronous online lectures may also be brought into on-site lectures with the use of augmented reality technologies (e.g., like the application “Lumilo”; Holstein, McLaren, & Aleven, 2019) to advance educational practises on- and off-site. External scripts can be designed to support teachers in their efforts to acquire internal schemas for online lectures, but also to guide students through the social activities expected from the teacher and needed to benefit most from learning from online lectures (Radkowitsch et al., 2020). Integrating automated adaptation of external scripts based on students’ input, behaviour, and provided personal data may be one way to go beyond the mere replication of face-to-face lectures in online learning environments. While online lectures are only one form of online teaching, they offer teaching that is similar to widely-used on-site lectures and may show benefits when teachers are sufficiently supported in the shift to online education. Learning Sciences’ research could inform the effort to support teachers in and beyond online lectures.

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References


Fostering Emotional Well-being and Resilience through Knowledge Building

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Abstract: Now more than ever, schools need to provide safe and supportive learning spaces that promote all students’ socio-emotional development and well-being. The current study investigates how Knowledge Forum can be used to extend classroom learning beyond school walls to enable asynchronous collaboration between two classrooms to foster digital citizenship and intercultural communication skills. Using sentiment analysis, we assessed students’ online discussions about family traditions during Christmas and their experiences during the Covid-19 quarantine in the spring. As expected, the Christmas discussion was generally more positive than the Covid-19 discussion, however, the Covid-19 discussion evolved from more negative to more positive. Additional analyses are underway to explore the extent to which magnitude of emotions travel within the community. Preliminary findings are interpreted within the context of designing socio-emotional learning assessments and computer-supported collaborative learning environments as schools move toward a hybrid model for the upcoming school year.

Keywords: Knowledge Building, Knowledge Forum, sentiment analysis, socio-emotional learning, emotional well-being

1. Introduction

Fostering mental health and emotional well-being in schools is a global educational priority (UNESCO, 2016). Consequently, educational researchers and policymakers have developed programs for educating the “whole child” in an effort to simultaneously support the academic, cognitive, psychological, social-emotional development of students (Darling-Hammond & Cook-Harvey, 2018). Such programs recognize that cognition and emotion work in tandem and highlight the importance of developing skills, habits, and mindsets that enable students to successfully self-regulate, engage in interpersonal interactions, persevere in face of challenges, and become resilient to adversity. For example, the Collaborative for Academic, Social, and Emotional Learning (2018) defines socio-emotional learning as “the process through which children understand and manage emotions, set and achieve positive goals, feel and show empathy for others, establish and maintain positive relationships, and make responsible decisions.” A recent review by Durlak and colleagues (2011) reinforces the notion that socio-emotional learning supports gains in academic achievement.

Despite existing resources and curricula for integrating socio-emotional learning into classroom practices, challenges exist with regards to assessment, including coordinating educational standards, balancing psychometric rigor with practical relevance, and integrating data-informed decision-making into professional learning programs (McKown & Taylor, 2018; McKown, 2019). Because there is no standardized approach for assessing socio-emotional learning, teachers are currently using a variety of methods, including self-report, rating scales, and direct observation. More recent work in the learning sciences point to the potential of machine learning and analytics for assessing the emotional tone and social presence of students in online communities (Zhu et al., 2020). More specifically, sentiment analysis, which uses natural language processing to detect the semantic orientation of written text, has been used to facilitate interpretation of student experiences as means to improve teaching and learning (Munezero et al., 2013; Rani & Kumar, 2017; Hew et al., 2020).
The current study is exploratory in nature and uses sentiment analysis to assess the emotional valence of online discussions between students in Knowledge Forum as means to visualize socio-emotional learning processes that took place before and during the Covid-19 pandemic. Because this work is part of a larger ongoing collaboration between two classrooms to foster digital citizenship through Knowledge Building in the social studies curriculum (Martin & Ma, under review), we focus our analyses on two specific discussions about students’ personal experiences – one about family traditions during Christmas and one about their experiences during the Covid-19 quarantine. Knowledge Building (Scardamalia & Bereiter, in press) has been shown to support students’ socio-emotional development and well-being. Recent work from Milinovich and Ma (2018) and Zhu and colleagues (2020) demonstrate that there is a strong culture of trust and psychological safety in Knowledge Building classrooms – students’ ideas are at the center of social interactions; students’ thoughts and experiences are validated by their peers; students take ownership of their learning by taking risks with ideas; and all are invited to extend ideas and integrate diverse perspectives towards deeper understandings. Within the context of social distance education, Knowledge Building pedagogy and Knowledge Forum technology offer a promising way for students to sustain meaningful relationships with their peers by sharing their experiences, empathizing with others’ experiences, and rising above superficial differences to acknowledge their shared humanity.

2. Data Sources and Analysis

During the 2019-2020 school year, 51 students in grade 6 (Ontario) and grade 7 (Mexico) studied human impacts on the environment using Knowledge Forum. Working asynchronously online, students wrote over 400 notes across 10 views on plastic pollution covering topics such as, “uses of plastics”, “advantages/disadvantages of plastics”, “thermoplastics”, “bioplastics”, and “government legislations for preventing plastic pollution”. On average, each student wrote 7 notes and read 27 notes, suggesting they were actively engaged in online discussions in Knowledge Forum. Social network analyses revealed a dense build-on network, with each student holding multiple ties, suggesting that the two classes had formed a cohesive community. For the current study, we conducted sentiment analyses then content analyses on student notes in two views – “Christmas experiences” (53 notes) and “Covid-19 experiences” (28 notes) – using the open-source Text2Data tool, which runs NLP on a pre-trained model based on online product reviews and service feedback. To our knowledge, this is the first time the Text2Data tool is being applied in an educational context, so we will also reflect on the strengths and weaknesses of this tool for educational purposes, especially with young children, in sections to follow.

Figure 1. Knowledge Forum a) view and b) word cloud of discussion about Christmas experiences.
Figure 2. Knowledge Forum a) view and b) word cloud of discussion about Covid-19 experiences.

3. Preliminary Findings

Figure 1 a) shows the Knowledge Forum view about Christmas experiences and Figure 2 a) shows the Knowledge Forum view about Covid-19 experiences. Figures 1b) and 2b) show automated word clouds generated by the sentiment analysis tool, which provide a visualization of the emotional contour for each view based on the distribution of positive sentiments (green) and negative sentiments (red). As expected, it can be seen that the Christmas view was generally more positive than the Covid-19 view because it has a larger proportion of green words than red words, with the opposite being true for the Covid-19 view. The word cloud also visualizes the evolution of emotions within a view (from top to bottom). Therefore, it is interesting to note that while the Covid-19 discussion was initially dominated by negative sentiments, such as fear (i.e., scared), toward the end of the discussion, there was an emergent sense of hope.

In the first Knowledge Forum view, students discussed family traditions during Christmas, which included visiting family and relatives, preparing special meals, decorating Christmas trees, exchanging gifts, playing games, and going to church. Students in Canada and Mexico were equally curious about the winter weather in each other’s countries and whether or not it was common for them to have a White Christmas like in the movies. Students in Mexico were especially drawn to this topic because they had never experienced snow before (e.g., “I wish to see a falling snow”, “I think that it is so beautiful!”). It is interesting to note, however, that while students were very enthusiastic about this topic, the sentiment tool picked up related keywords as indicating a negative sentiment (e.g., “cool but cold, “cold in Canada”). In the second Knowledge Forum view, students discussed their experiences while in quarantine, which included spending time with family, cooking, exercising, playing games, watching television, and taking online classes. As expected, the discussion in this view was more emotionally charged, as students expressed that they were feeling stressed, sad, and/or scared, bored at home, missing their friends, and generally concerned for their family members – some of which were essential workers and others who were laid off from work. While some students tried to be pro-active by sharing health tips like “wash our hands often”, “don’t touch our faces often”, and “use moisturizer to prevent your hands from being dry”, others tried raising morale by saying things like, “Stay safe and stay strong”, “It is good that you care about your mother”, “I am very happy for the family I have”, and “Hopefully this will all be over soon.”

Additional analyses are underway to explore the extent to which emotions travel within the community to support learning. Table 1 shows excerpts of student notes from both views as well as their corresponding sentiment scores and magnitude of emotionality. Whereas sentiment scores indicate the overall emotional leaning of the note, ranging from positive (1.0) to negative (-1.0), magnitude indicates the overall strength of emotion within the note (ranging from 0 to infinity). For example, while the sentences “In Canada we celebrate with family and gifts.” and “MERRY CHRISTMAS
EVERYONE!” have the same sentiment score (0.58), which suggests that they are equally positive, the magnitude of the first sentence is higher, suggesting that it conveys a stronger amount of emotion than the latter sentence. In a similar way, the sentences “It is good that you care about your mother.” and “I’m really starting to miss my friends.” have the same magnitude score (0.70), which suggests that they are equally emotional despite conveying opposite sentiments. We hypothesize that magnitude of emotionality in different contexts may demonstrate students’ growing ability to express their emotions and regulate socio-emotional processes. To address this, we are developing student profiles based on sentiment analyses and qualitative assessments of emotions using the CASEL (2018) framework for socio-emotional learning.

Table 1. Excerpts of Students’ notes, Sentiment scores, and Magnitude

<table>
<thead>
<tr>
<th>Notes about Christmas Experiences</th>
<th>Sentiment</th>
<th>Magnitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>In Canada we celebrate with family and gifts.</td>
<td>0.58</td>
<td>0.90</td>
</tr>
<tr>
<td>How I celebrate Christmas is to be with my family and celebrate the birth of Jesus Christ.</td>
<td>0.54</td>
<td>0.81</td>
</tr>
<tr>
<td>I think that it is so beautiful!</td>
<td>0.62</td>
<td>0.81</td>
</tr>
<tr>
<td>One of my family’s traditions is on Christmas Eve we do a scavenger hunt on Christmas Eve to find clues that will lead to a gift for each of us me and my three sisters that we can open that night.</td>
<td>0.54</td>
<td>0.76</td>
</tr>
<tr>
<td>MERRY CHRISTMAS EVERYONE!</td>
<td>0.58</td>
<td>0.73</td>
</tr>
<tr>
<td>Christmas in Canada is cool but cold.</td>
<td>-0.51</td>
<td>0.83</td>
</tr>
<tr>
<td>One of my Christmas traditions is not eating meat on Christmas Eve so my grandmother makes fish and seafood and it’s really good.</td>
<td>-0.56</td>
<td>0.81</td>
</tr>
<tr>
<td>With the family of my mom, they do like a dance, and they light fireworks, but I don’t like it.</td>
<td>-0.54</td>
<td>0.66</td>
</tr>
<tr>
<td>Here in Mexico it’s cold because it’s winter but I think it’s not so cold like there in Canada.</td>
<td>-0.57</td>
<td>0.75</td>
</tr>
<tr>
<td>We have been getting snow for like the past two months, but it has been coming and going.</td>
<td>-0.49</td>
<td>0.58</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Notes about Covid-19 Experiences</th>
<th>Sentiment</th>
<th>Magnitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am also really enjoying time with my family and we are spending more time together than ever.</td>
<td>0.54</td>
<td>0.77</td>
</tr>
<tr>
<td>I hope we go back to school soon.</td>
<td>0.53</td>
<td>0.74</td>
</tr>
<tr>
<td>It is good that you care about your mother.</td>
<td>0.52</td>
<td>0.70</td>
</tr>
<tr>
<td>I also always thank for everything I have.</td>
<td>0.57</td>
<td>0.68</td>
</tr>
<tr>
<td>I am very happy for the family I have.</td>
<td>0.52</td>
<td>0.60</td>
</tr>
<tr>
<td>My experience with this pandemic is that I only stay in my house and I try to do a lot of things to not be bored like exercise.</td>
<td>-0.53</td>
<td>0.85</td>
</tr>
<tr>
<td>Hearing about this very sad news makes me sad.</td>
<td>-0.50</td>
<td>0.77</td>
</tr>
<tr>
<td>And I am living in worry for my Grandpa, aunt, stepdad, and dad, since my dad and stepdad are police and experiencing COVID 19 first hand.</td>
<td>-0.47</td>
<td>0.76</td>
</tr>
<tr>
<td>I’m really starting to miss my friends.</td>
<td>-0.51</td>
<td>0.70</td>
</tr>
<tr>
<td>I also worry about her.</td>
<td>-0.54</td>
<td>0.64</td>
</tr>
</tbody>
</table>

4. Discussion

Now more than ever, schools need to provide safe, supportive, and equitable physical as well as digital learning spaces that promote all students’ socio-emotional development (CASEL, 2020). The reopening of schools during the Covid-19 pandemic represents an opportunity to adopt evidence-based practices from the learning sciences to redesign schools toward more equitable outcomes. Recommendations include (but are not limited to): ensuring supports for social and emotional learning, strengthening relationships between students, teachers, and parents, and emphasizing authentic, culturally responsive learning (Darling-Hammond et al., 2020).
Digital technologies, like Knowledge Forum, will also continue to play a critical role in extending the classroom beyond school walls so that students may engage in sustained interactions with their teachers and peers over time. For example, asynchronous online learning environments will allow students who are not able to attend school to participate in discussions. Additionally, analytic tools, such as social network analysis and sentiment analysis, can be used to support socioemotional learning through the development of positive peer relationships and a sense of community. In the current study, Knowledge Building/Knowledge Forum was used to connect two classrooms—one in Canada and one in Mexico—to foster digital citizenship and by extension, intercultural communication. By inviting students to share their personal experiences and read about other student’s experiences, students came to realize that they had many commonalities despite their age, language, and geographical differences. Although fostering digital citizenship may not be an immediate educational priority during a global pandemic, this study suggests there is possible overlap with socio-emotional learning. Future work can explore how the designs of asynchronous online learning environments can support the coordinated development of these 21st century competencies toward shaping students’ identities as engaged, global digital citizens.

The current global pandemic also offers new opportunities for learning scientists to work with teachers and students around the world to re-design online interactions and structures toward productive forms of engagement around ideas and emotions in ways that empower students to take on higher levels of agency for their learning. Design research in classrooms illustrate that grade 3 and grade 6 students can use analytic tools in Knowledge Forum with ease to engage in self-regulation and co-regulation of group processes during Knowledge Building (Ma, Akyea, & Martin, accepted). For example, word clouds that visualize the most common words, have been used by students to promote reflections about “big ideas” in their community knowledge. This study adds that word clouds that visualize positive and negative sentiment have the potential to provide teachers and students with just-in-time feedback about their socio-emotional learning processes. For example, notes with high magnitude of emotionality can be used to prompt discussions around empathy and perspective-taking, as well as effective communication and emotional regulation strategies. Additional design research is needed to understand how teachers and students interpret sentiment analysis in meaningful ways, including discussions surrounding its limitations (e.g., How do positive/negative sentiments help us learn? What do neutral sentiments mean? What other emotions have been expressed but are not represented in these visualizations?).

While sentiment analysis offers a promising way to trace the evolution of the socio-emotional dynamics in online discussions, it should be used with caution, especially with young students and students in marginalized groups. McKown (2019) warns that “Any tool, including SEL assessment, can be assimilated into ill-conceived or harmful purpose, such as inappropriately attributing inequity to the skill deficits of a group”. For example, Figure 1b) marks “spoke Spanish” as a negative sentiment even though there was no negative perception of these words from students in Ontario or Mexico. In fact, students in Mexico were teaching students in Ontario certain family traditions and taught them a few Spanish words, such as “abuela” (grandma), “regalos” (gift), and “navidad” (Christmas). Therefore, if sentiment analysis is to be used to support assessment of socio-emotional learning and student well-being in classrooms, NLP models will need to checked for biases and retrained on more representative corpora. Given the rising priority of fostering student well-being and emotional resilience in social distance education, more research is needed at the intersection of the design of socio-emotional learning assessments and computer-supported collaborative learning environments.
References


The Digital Divide among Students and Support Initiatives in the Time of Covid-19

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Abstract: This paper investigated the digital divide among students of a state university in the Philippines in relation to its implementation of technology-led flexible learning due to the CoViD-19 pandemic. The study focused on two major factors of the digital gap: location (urban vs rural) and socio-economic (income clusters). Results provided further evidence that geographic location and income affect digital inequality among students. Both aspects have an impact on device ownership, stable internet connection at home, and frequency of access. Prior online learning experience also shows dependency on a student’s geographic location. Location groups and the alternative ways to access the internet have a significant relationship where students from urban areas are more likely to spend money for temporary data subscription, go to internet cafes, or use their neighbor’s, friends’, and relative’s Wi-Fi connection. On the other hand, those from rural areas are more likely to utilize free data and free Wi-Fi in public areas or have no other means to connect at all. The students were also categorized based on the context of flexible learning implementation of the university: those with device and with connectivity, with device but no connectivity, no device and no connectivity. For each category, different support initiatives were developed including utilization of school’s ICT facilities, funds for internet subscription, and tablet lending. The study emphasized that school administrators and teachers must take digital divide into consideration in crafting instruction, support guidelines, and policies for flexible learning. A follow up study is also recommended to validate the effectiveness of the university’s ICT support initiatives presented in this paper.

Keywords: Digital Divide, CoViD-19, ICT, Flexible Learning

1. Introduction

The unprecedented effect of the corona virus disease 2019 or the CoViD-19 pandemic has taken further the utilization of digital technologies in various aspects due to government advisories restricting face-to-face interactions and mass gatherings (Beaunoyer et al., 2020; Guitton, 2020). One of the most affected by this is the education sector where institutions are now forced to implement alternative modes of instruction delivery which significantly involves information communications technologies (ICT). The use of ICT in education is not new as even prior to CoViD-19, most of the schools have been using computer-based and online systems for course enrollment, scholarships facilitation, communication with students, electronic databases or digital libraries, and instruction (Goode, 2010). Indeed, ICT played a significant role as a pedagogical technique in the past decades or so which led to students’ improved engagement in the meaningful use of computers and the internet (Sanchez & Aleman, 2011). It also brought enhancements on the quality of education with advanced pedagogical methods, improvement of learning outcomes and reformation for better management of education systems (Sarkar, 2012).

However, the issues of inequality between individuals and socio-economic groups when it comes to their capability to access these technologies remain to be a hindrance for the full utilization of ICT (Buchi et al., 2018; DiMaggio & Hargittai, 2001; Hargittai, 2010). Hence, with the use of ICT in education, not all students are able to experience the benefits of technology in their learning experiences (Goode, 2010). This has important implications for developing countries, like in the Philippines, where students from rural areas believe that they don’t have sufficient access to technology at home to be used in education and that their primary venue to access technology is in their school (Talandron-Felipe,
This poses a significant problem in today’s situation due to CoViD-19 as face-to-face classes are restricted and students who are allowed in the campus are limited (CHED, 2020; IATF, 2020). This paper aims to investigate the extent of the digital gap among students from a state university in a developing country in its implementation of a technology-driven flexible learning program and how the institution plans to mitigate it.

2. Digital Divide

The term “digital divide” was first introduced in the 1990’s by former Assistant Secretary of Commerce for Telecommunication and Communication in the US to give attention to the gap between those who can afford to own a computer system to take part in the global information network and those who cannot (Boje & Dragulanescu, 2003). It was then formally defined by the Organization for Economic Co-operation and Development (OECD, 2001) as “the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard to both their opportunities to access ICTs and to their use of the Internet for a wide variety of activities”. Over the years, multiple definitions of digital divide exist but inequalities can be put into context as emerging from the differences in two aspects: actual access and digital literacy to utilize the technology (Beaunoyer et al., 2020). Studies show that gender, race, socioeconomic status, geographical location, (dis)ability, educational level are associated with disparities in those aspects (Ferro et al., 2011; Hilbert, 2011; Hill et al., 2015; Novo-Corti et al., 2014; Wu et al., 2014). This means that people who belong to these groups are more likely to have no or limited accessibility to technologies and are denied of educational and socioeconomic opportunities (Gatautis, 2015).

Global projects such as the ‘One Laptop per Child’ and the ‘Hole in the Wall’ have exemplified initiatives to help increase ICT access for disadvantaged children in Africa and South East Asia (DISE, 2010; Hole in the Wall, 2010; One laptop per child, 2010). These are in conjunction to UNESCO’s aim to empower the people through information and media literacy as an essential precondition for equitable access and inclusive knowledge societies (UNESCO, 2010). However, most of these initiatives are limited within the compounds of the institution and despite ICT access at school, individual differences and home access still affect learners’ use and skills (Gudmundsdottir, 2010). One example of promoting ICT access at home was made by the Hong Kong Government in 2011 through their five-year “I Learn at Home” program to assist students purchase computers and pay for broadband services at home (Yuen & Park, 2012).

In today’s situation, low-income household are expected to suffer more the immediate and long-term economic consequences of the COVID-19 crisis (Fernandes, 2020; Van Lancker & Parolin, 2020; Wang & Tang, 2020). Considering this, purchasing ICT equipment or internet subscription for their children’s online classes will unlikely be a priority in the budget of these families unless they sacrifice spending on their essentials like food, water, clothing, and other household expenses (Beaunoyer et al., 2020). Specifically, in a developing country like the Philippines, prior work found a strong correlation between the combined household income and owning a computer system and access to internet (Talandron et al., 2016).

Aside from income, another significant factor affecting individual’s access to ICTs is geographic location in developing countries where those living in rural areas are expected to lag behind those from urban areas because of limited telecommunication infrastructure, availability of equipment, and culture (Aciyar, 2011; Hindman, 2000; Talandron et al., 2016; Talandron-Felipe, 2019). Even in a developed country, it was found that urban children had better conditions/performances in every aspect of Internet behavior than rural children and in total, 99% of urban children owned a PC at home, while less than two thirds of rural children owned a PC at home (Li & Ranieri, 2013). Another study in the Mid-Atlantic state in the United States showed that high poverty rates are common in rural settings, which has a negative impact technological resources (Kormos, 2018). The report by Federal Communications Commission ( 2018) showed that within the United States, 31% of rural households still lack access to broadband Internet. These findings support that digital divide because of geographic
disparity also exist in developed nations although possibly not as much as in developing countries (Aciyar, 2011).

3. Data Collection

A survey was conducted in a state university in southern Philippines. Students come from the region composed of five provinces with 9 urban cities and 84 rural municipalities. The total number of students of the state university was 13,405 with 9,022 (67%) from urban areas and 4,383 (33%) from rural areas. Sample sizes from both areas were computed with 95% confidence level and 2% margin of error to determine the number of respondents. The computed sample sizes were 1,897 and 1,552 for urban and rural areas respectively for a total of 3,449 respondents. The students to be surveyed for each category, composed of senior high school and freshmen to senior college, were chosen through simple random technique. The survey was conducted during the enrollment period and was done in various ways in order to cater the students who do not have access to the internet at the time. Students were given the options to answer it online, send in their answers through private message using free data, through SMS, or through phone call.

The survey was designed based on the concept of ICT Development Index (IDI), Digital Access Index (DAI) and Digital Opportunity Index (DOI) (Telecommunications Authority of Trinidad and Tobago, 2013). IDI includes questions and answers about access, skills, and usage; DAI includes knowledge, infrastructure, and affordability; and DOI is about opportunity and utilization. This was the simplified version from DiMaggio & Hargittai’s (2001) model of internet inequality as a framework to measure the levels of digital divide in five aspects: 1) inequality in owning the appropriate equipment to access the internet; 2) inequality in autonomy of use which means one’s ability to control when and where one wants to use the ICT resources; 3) inequality in the availability of support, both technical and non-technical; 4) inequality in the availability of options for the variation of use considering the purpose and activity; and 5) inequality in computer literacy and skills. Considering the concept and framework mentioned, the goal of the survey was to determine the gadget and connectivity capability of the students at home, their prior experience with online learning platforms, and self-assessment of their need for support in navigating an online learning environment.

4. Results and Discussion

4.1 Location-based Digital Divide

A comparison was made between students from urban areas (urban group) and students from rural areas (rural group) in terms of ICT device ownership, frequency of access to the internet, computer literacy, and prior experience with online learning. Table 1 shows the frequency counts or observations for each group in each indicator.

Table 1. Comparison of various ICT capabilities between Students from Urban and Rural areas

<table>
<thead>
<tr>
<th>Categories</th>
<th>Indicators</th>
<th>Urban Observations</th>
<th>Urban (%)</th>
<th>Rural Observations</th>
<th>Rural (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device Ownership (can own multiple)</td>
<td>Desktop/Laptop Computer</td>
<td>729</td>
<td>38%</td>
<td>556</td>
<td>36%</td>
</tr>
<tr>
<td></td>
<td>Tablet</td>
<td>31</td>
<td>2%</td>
<td>42</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>Smartphone</td>
<td>1725</td>
<td>91%</td>
<td>1398</td>
<td>90%</td>
</tr>
<tr>
<td></td>
<td>No Device</td>
<td>35</td>
<td>2%</td>
<td>39</td>
<td>3%</td>
</tr>
<tr>
<td>Stable internet connection at home</td>
<td>With stable internet at home</td>
<td>790</td>
<td>42%</td>
<td>566</td>
<td>36%</td>
</tr>
</tbody>
</table>
A chi-square test of independence was performed to examine the relationship between location and the indicators per category. On device ownership, the relationship was significant, $X^2 (3, N=4555) = 7.852, p=0.049172$. Students from urban areas were more likely to own ICT devices. On internet connection at home, the relationship was also significant, $X^2 (2, N=3449) = 20.3252, p<0.0001$. Students from urban areas were more likely to have or willing to spend for a stable internet connection at home. On the third category, the relationship was also significant, $X^2 (3, N=3449) = 13.9537, p=0.0029$. Students from urban areas have more frequent access to the internet than students from rural areas. When it comes to computer literacy (basic word processing, digital presentations, photo and video editing), the relationship with location was not significant, $X^2 (1, N=5377) = 0.0117, p=0.9139$. This is somewhat expected because these skills are common to be taught in schools, way before CoViD-19, regardless of where the students came from. On the last category, prior online learning experience, the relationship was significant, $X^2 (5, N=12319) = 36.5025, p<0.0001$. Students from urban areas were more likely to have been previously exposed to online learning experiences.

### 4.2 Income-based Digital Divide

A comparison was made between students from various income clusters in terms of ICT device ownership, frequency of access to the internet, computer literacy, and prior experience with online learning. It is also important to note that before this analysis was made, the relationship between location groups and income clusters were tested and the result was not significant, $X^2 (3448, N=3449) = 1658.93, p=1.00$, which means these two factors are independent from each other. The income clusters were based from the Philippine Institute for Development Studies Policy Notes (PIDS, 2018). Table 2 shows the frequency counts or observations for each group in each indicator.
Table 2. Comparison of various ICT capabilities between Students from different income clusters

<table>
<thead>
<tr>
<th>Categories</th>
<th>Indicators</th>
<th>Upper middle - income 1500-2500USD/Month for a family of 5</th>
<th>Middle middle - income 850-1499USD/Month for a family of 5</th>
<th>Lower middle - income 430-549USD/Month for a family of 5</th>
<th>Low income 215-429USD/Month for a family of 5</th>
<th>Poor &lt;215USD/Month for a family of 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device Ownership (can own multiple)</td>
<td>Desktop/Laptop Computer</td>
<td>504 47%</td>
<td>484 47%</td>
<td>210 26%</td>
<td>40 15%</td>
<td>44 16%</td>
</tr>
<tr>
<td></td>
<td>Tablet</td>
<td>30 3%</td>
<td>28 3%</td>
<td>10 1%</td>
<td>4 1%</td>
<td>1 0%</td>
</tr>
<tr>
<td></td>
<td>Smartphone</td>
<td>984 92%</td>
<td>944 92%</td>
<td>728 90%</td>
<td>233 85%</td>
<td>229 84%</td>
</tr>
<tr>
<td></td>
<td>No Device</td>
<td>4 0%</td>
<td>8 1%</td>
<td>24 3%</td>
<td>22 8%</td>
<td>20 7%</td>
</tr>
<tr>
<td>Stable internet connection at home</td>
<td>With stable internet at home</td>
<td>670 63%</td>
<td>622 61%</td>
<td>53 7%</td>
<td>8 3%</td>
<td>3 1%</td>
</tr>
<tr>
<td></td>
<td>None but willing to spend</td>
<td>402 38%</td>
<td>403 39%</td>
<td>470 58%</td>
<td>3 1%</td>
<td>9 3%</td>
</tr>
<tr>
<td></td>
<td>None and there is no to have</td>
<td>0 0%</td>
<td>0 0%</td>
<td>284 35%</td>
<td>262 96%</td>
<td>260 96%</td>
</tr>
<tr>
<td>Frequency of access regardless of where or how</td>
<td>Daily/every other day</td>
<td>862 80%</td>
<td>813 79%</td>
<td>345 43%</td>
<td>69 25%</td>
<td>54 20%</td>
</tr>
<tr>
<td></td>
<td>Twice a week</td>
<td>118 11%</td>
<td>125 12%</td>
<td>249 31%</td>
<td>105 38%</td>
<td>99 36%</td>
</tr>
<tr>
<td></td>
<td>Once a week</td>
<td>60 6%</td>
<td>47 5%</td>
<td>109 14%</td>
<td>52 19%</td>
<td>72 26%</td>
</tr>
<tr>
<td></td>
<td>Depends on chance/money</td>
<td>32 3%</td>
<td>40 4%</td>
<td>104 13%</td>
<td>47 17%</td>
<td>47 17%</td>
</tr>
<tr>
<td>Computer literacy (Self-assessment)</td>
<td>Can create documents and presentations</td>
<td>892 83%</td>
<td>863 84%</td>
<td>677 84%</td>
<td>217 79%</td>
<td>216 79%</td>
</tr>
<tr>
<td></td>
<td>Can make/edit photos/videos</td>
<td>804 75%</td>
<td>768 75%</td>
<td>558 69%</td>
<td>196 72%</td>
<td>186 68%</td>
</tr>
<tr>
<td>Prior online learning experience</td>
<td>Attended a class or did an activity via social media and/or learning management system?</td>
<td>587 55%</td>
<td>517 50%</td>
<td>361 45%</td>
<td>87 32%</td>
<td>97 36%</td>
</tr>
<tr>
<td></td>
<td>Submitted assignments online</td>
<td>716 67%</td>
<td>697 68%</td>
<td>512 63%</td>
<td>148 54%</td>
<td>142 52%</td>
</tr>
<tr>
<td></td>
<td>Taken online quizzes/exams</td>
<td>875 82%</td>
<td>828 81%</td>
<td>613 76%</td>
<td>185 68%</td>
<td>173 64%</td>
</tr>
<tr>
<td></td>
<td>Attended online classes through video conference</td>
<td>704 66%</td>
<td>656 64%</td>
<td>450 56%</td>
<td>135 49%</td>
<td>116 43%</td>
</tr>
<tr>
<td></td>
<td>Engaged in collaborative activities online with classmates</td>
<td>634 59%</td>
<td>594 58%</td>
<td>420 52%</td>
<td>133 49%</td>
<td>113 42%</td>
</tr>
<tr>
<td></td>
<td>Responded to online forums</td>
<td>646 60%</td>
<td>609 59%</td>
<td>428 53%</td>
<td>119 44%</td>
<td>101 37%</td>
</tr>
</tbody>
</table>
A chi-square test of independence was also performed to examine the relationship between income clusters and the indicators per category. For the first category, the relationship was significant between device ownership and income, $X^2 (12, N=4555) = 242.9193, p<0.0001$. Another significant relationship with income clusters was having internet connection at home, $X^2 (8, N=3449) = 2715.8746, p<0.0001$ and frequency of access to the internet, $X^2 (12, N=3449) = 795.9385, p<0.0001$. However, no significant relationship was found with income clusters on computer literacy and prior online learning experience, $X^2 (4, N=5377) = 1.7053, p=0.7897$ and $X^2 (20, N=12319) = 14.9957, p=0.7766$, respectively.

### 4.3 Device and Connectivity Capability

On the question on having a regular and stable internet connection at home, 37% (1,287 out of 3499, composed of 717 from urban, 570 from rural) answered “None currently, but we are willing/planning to spend for a connection at home” and 23% (806 out of 3499, composed of 390 from urban and 416 from rural) answered “None – there is no way for us to have internet connection at home” for a total of 2,093 (60%). These students were asked if they have an alternative way to connect to the internet. Responses were grouped into five: free data/free Wi-Fi in public areas, temporary subscription through prepaid load, computer shop or internet café, neighbor’s/friends’/relative’s Wi-Fi, and none (no other way). Table 3 shows the urban-rural comparison on the alternative ways to access the internet since a regular and stable connection is not available at home.

<table>
<thead>
<tr>
<th>Alternative way to access the Internet</th>
<th>Urban (out of 1109)</th>
<th>Rural (out of 986)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free Data/Free Wi-Fi in Public Areas</td>
<td>83 (7%)</td>
<td>124 (13%)</td>
</tr>
<tr>
<td>Temporary Subscription through prepaid load</td>
<td>332 (30%)</td>
<td>274 (28%)</td>
</tr>
<tr>
<td>Computer Shop/Café</td>
<td>350 (32%)</td>
<td>294 (30%)</td>
</tr>
<tr>
<td>Neighbor’s/Friends'/Relative’s Wi-Fi</td>
<td>340 (31%)</td>
<td>289 (29%)</td>
</tr>
<tr>
<td>None</td>
<td>2 (0.2%)</td>
<td>5 (1%)</td>
</tr>
</tbody>
</table>

The relationship between group classification (urban vs rural) and the alternative way to access the internet was also measured and a significant relationship was found, $X^2 (4, N=2093) = 17.0240, p=0.0019$. Students from urban areas were more likely to spend for temporary data subscription, go to internet cafés, or use their neighbor’s, friends’, and relative’s Wi-Fi. On the other hand, those from rural areas were more likely to utilize free data and free Wi-Fi in public areas or have no other means to connect at all.

The same was investigated in terms of income clusters. Table 4 shows the comparison on the alternative ways to access the internet since a regular and stable connection is not available at home based on income clusters.

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Upper middle-income</th>
<th>Middle middle-income</th>
<th>Lower middle-income</th>
<th>Low-income</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$1,500-2,500 USD/Month for a family of 5</td>
<td>$850-1,499 USD/Month for a family of 5</td>
<td>$430-549 USD/Month for a family of 5</td>
<td>$215-429 USD/Month for a family of 5</td>
<td>$&lt;215 USD/Month for a family of 5</td>
</tr>
<tr>
<td>out of 402</td>
<td>out of 403</td>
<td>out of 754</td>
<td>out of 265</td>
<td>out of 269</td>
<td></td>
</tr>
</tbody>
</table>
The chi-square test of independence was also used to check the relationship between income clusters and alternative ways to connect to the internet. The result was significant, $X^2 (16, N=2093) = 46.0760, p<0.0001$. Those from upper middle to lower middle-income tend to spend more on temporary internet subscription through prepaid load while those from low-income and poor tend to utilize more the free data or free Wi-Fi in public places.

4.4 Digital Divide and CoViD-19 Restrictions

As the results show, location-based and income-based digital divide exist among the students and this should be taken into consideration when schools develop policies on flexible learning in this time of crisis. More so, CoViD-19 safety protocols may widen the gap as going out and traveling restrictions are in place (IATF, 2020). Students who need to go to public places or their friends’ or relatives’ houses to connect to the internet may no longer be allowed to do so. Similarly, income-based digital divide may also worsen as the Philippine economy is continuously declining (Estadilla, 2020). As previously mentioned, low-income households are the ones anticipated to be impacted by the economic consequences of the COVID-19 crisis (Fernandes, 2020; Van Lancker & Parolin, 2020; Wang & Tang, 2020).

Aside from geographic location and income clusters affecting the digital divide among the students, CoViD-19 related restrictions are also making it more difficult for students to find alternative ways to access ICT for their education. The Inter-Agency Task Force in the Philippines restricts those who are below 21 years old to go outside and inter-provincial travels requires quarantine protocols (IATF, 2020). These limitations prevent the university from utilizing its in-campus ICT facilities for students below 21 years old and those living from other provinces who do not have devices and connectivity capability at home. Table 5 shows the matrix developed to classify students based on device and connectivity capability and specific quarantine circumstance and the distribution of the respondents.

<table>
<thead>
<tr>
<th>Circumstance (Based on Quarantine Protocols)</th>
<th>Owns a device and has stable internet access at home</th>
<th>Owns a device but has no stable internet access at home</th>
<th>No device and has no stable internet access at home</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 years old &amp; above and resides within the province (may go to school)</td>
<td>17 (5%)</td>
<td>240 (7%)</td>
<td>1 (0.03 %)</td>
</tr>
<tr>
<td>21 years old &amp; above but resides outside the province (difficult to travel)</td>
<td>42 (1%)</td>
<td>175 (5%)</td>
<td>11 (0.3%)</td>
</tr>
</tbody>
</table>
Students who own a device and has stable internet access at home are considered to be capable of synchronous learning with the assumption that other considerations such as the availability of a study place and other home-related aspects are not a problem. Although flexible learning is a combination of both synchronous and asynchronous activities, efforts to provide ICT support should be prioritized for students who own a device but has no stable internet access at home and those without both device and connectivity.

4.5 Initiatives to Support the Students

Based on the findings, support to students will be classified into two types: connectivity support and both device & connectivity support. It is also important to note that school funds of state universities are limited and affected by the pandemic and this should be taken into consideration. Even though face-to-face classes are restricted (CHED, 2020), school’s ICT facilities may still be utilized by students who are 21 years old and above who reside within the province and will not have difficulty to go to the campus. Scheduling and strict safety protocols are to be implemented for this type of support. For those who live outside the province, the university will partner with internet cafes and computer shops as a venue for students who are 21 years old and above and may go out of their homes. For those who are below 21 years old and are strictly advised to stay home (IATF, 2020), the university shall provide support through tablet lending and temporary internet subscription. Table 6 shows a summary of the various types of support depending on device and connectivity capability and specific quarantine protocols.

Table 6. ICT Support Initiatives

<table>
<thead>
<tr>
<th>Circumstance (Based on Quarantine Protocols)</th>
<th>Owns a device but has no stable internet access at home</th>
<th>No device and has no stable internet access at home</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 years old &amp; above and resides within the province (may go to school)</td>
<td>Support for connectivity – may utilize campus Wi-Fi hotspots</td>
<td>Support for device and connectivity – may utilize campus computers and Wi-Fi hotspots</td>
</tr>
<tr>
<td>21 years old &amp; above but resides outside the province (difficult to travel)</td>
<td>Support for connectivity – scheduled prepaid load may be provided by the school for internet subscription</td>
<td>Support for device and connectivity – the school will provide vouchers so students may utilize nearby internet cafes for computers and stable connection</td>
</tr>
<tr>
<td>Below 21 years old (should stay at home)</td>
<td>Support for connectivity – scheduled prepaid load may be provided by the school for internet subscription</td>
<td>Support for device and connectivity – priority for tablet with network sim card or laptop with pocket Wi-Fi lending program</td>
</tr>
</tbody>
</table>

5. Conclusion and Recommendation

A state university in southern Philippines, a developing country in Asia, conducted a study to investigate the digital divide among its students. The study focused on two major factors of the digital gap: location (urban vs rural) and socio-economic (various income clusters). Results are consistent with findings from prior research that geographic location (Acılar, 2011; Hindman, 2000; Li & Ranieri, 2013; Talandron et al., 2016; Talandron-Felipe, 2019) and income (Ferro et al., 2011; Hilbert, 2011; Hill et al., 2015;
Novo-Corti et al., 2014; Wu et al., 2014) affect digital inequality. Both aspects impacted device ownership, having stable internet connection at home, and frequency of access while prior online learning experience showed dependency on location. A significant relationship was also found between locations groups (urban vs rural) and the alternative way to access the internet where students from urban areas were more likely to spend for temporary data subscription, go to internet cafes, or use their neighbor’s, friends’, and relative’s Wi-Fi. On the other hand, those from rural areas were more likely to utilize free data and free Wi-Fi in public areas or have no other means to connect at all. Then, the students were categorized based on the context of flexible learning implementation of the university: with device and with connectivity, with device but no connectivity, no device and no connectivity. For each category, the university came up with different support initiatives to be provided to the students including utilization of school’s ICT facilities, funds for internet subscription, and tablet lending.

This study also contributed to digital divide literature by providing more evidence as to the ICT capability of students in both urban and rural areas from different income clusters to emphasize that digital inequalities exist and could affect the implementation of flexible learning more so of online learning and the conduct of synchronous activities. It is suggested that school administrators take these into consideration in crafting support guidelines and policies. Teachers should also take into account the ICT profile of students in designing tasks especially synchronous activities. A follow up study is also recommended to validate the effectiveness of the ICT support initiatives presented in this paper in relation to the students’ flexible learning experience.

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Loneliness, Boredom and Information Anxiety on Problematic Use of Social Media during the COVID-19 Pandemic

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Abstract: COVID-19 is a global health concern with emerging economies expected to endure lasting effects. Massive information in social media while beneficial for some is perceived to have caused unnecessary anxiety for others. Although research on technological factors and their relationships to social media adoption is well documented, limited studies explored the psychology behind problematic use of social media especially during a health crisis. Analyzing survey responses from 257 participants, we tested the influence of loneliness, boredom and information anxiety on the problematic use of social media during the COVID-19 health crisis. Structural regression analysis supported prior literature that boredom and anxiety positively influence the escalation of problematic social media use. Although previous findings support the influence of loneliness on problematic social media use, this cannot be supported within the context of this study. We conclude this paper by discussing the implications of our study to informal education while highlighting the limitations of the study to provide directions for future scholarly endeavors.

Keywords: Problematic Social Media Use, Facebook, COVID-19 Pandemic, Information Anxiety, Loneliness, Boredom

1. Introduction

The affordance of social media as a primary source of information and misinformation created an ambivalent situation which remains to be unsolved. In the past, mankind acquired relevant news from traditional forms of media technology such as the television and radios. Wider internet penetration and increased social media popularity ushered in a new generation of information consumers who prefer getting news from social media, share opinions in public spaces and participate in a wide array of social interactions (C. Chan & Suarez, 2017; Fletcher & Nielsen, 2019; Ramos, Suarez, & Tighe, 2019). When a crisis unfolds, individuals prefer to learn news and updates from social media (e.g., Twitter, Facebook) due mostly to its accessibility and speed. In a 2016 study, Pew Research Center reported that the majority of US adults (62%) get news from social media (Shearer & Gottfried, 2016).

During crisis, social media is an alternative platform for individuals and communities to stay connected without physical interactions. With this, an enormous spike of people was observed to have spent excessive time online, reading news, and using social media platforms to get updated on any outbreak-related information. We Are Social (2020) revealed that countries with the strictest quarantine or lockdown measures, experienced a significant increase in social media use, mainly attributed to plenty of spare time. However, excessive use of these social media platforms impair social activities, decrease productivity, affect interpersonal relationships, and negatively affect the general well-being (Shensa et al., 2017). To this date, one of social media’s challenge as a resource for updates is the lack...
of appraisal on the accuracy and reliability of the shared information. Individuals are at risk of any rumors and opposing information from different accounts on the social media platform causes them to be more anxious or distressed (Jones, Thompson, Schetter, & Silver, 2017). For this, we draw on a previous health crisis in which overly exposure to any media coverage for acquiring event information may have unintended consequences for mental health and psychological well-being.

Although social media usage has many potential benefits to any individual, concerns have been raised on the possible adverse effects of uncontrolled social media’s activities, especially for individual mental health and well-being (Bányai et al., 2017). A study from Casale & Banchi (2020) has found positive associations between intensive social media use and symptoms of psychological disorder (e.g., anxiety or depressive symptoms). Other researchers argue that excessive or problematic social media use is an individual response to common stressors or losses (Carbonell & Panova, 2017). The existence of inaccurate or exaggerated information from the media coupled with political discourses may result in anxiety among individuals seeking health information, causing them to display maladaptive behaviors (e.g., sharing unverified health information, repeated consultation to untrusted parties) (Rajkumar, 2020). Individuals may exhibit these behaviors because of their inability to access or understand the needed information due to the insufficient or overloaded information, disorganized or wrongly presented information (Girard & Allison, 2015). The excessive use of social media platforms to be informed on any issues surrounding this pandemic and the underlying stress of using it is highlighted by the World Health Organization’s calls to be cautious of any unverified information from social media (WHO, 2020).

In this research, we investigate the influence of psychological factors on the escalation of social media’s problematic use during the pandemic to address several opportunities for further study. Curation of prior studies reveal the lack of study on the exploration of psychological factors such as loneliness, boredom and information anxiety in the problematic use of social media during health crises, with most studies primarily focused on the association between individual personalities and excessive internet use (Casale & Banchi, 2020). We contribute to current studies by identifying the avenues to which we draw our motivation in conducting this study. First, prior studies revealed that extant research was conducted in developed economies even though emerging economies in the Asia Pacific use social media the most (Balhara, Mahapatra, Sharma, & Bhargava, 2018). Second, social media use is popular among different social clusters but most research focused on age groups belonging to adolescents and university students. Understanding the general public overly used of social media during the natural disasters remain under-investigated (Baloran, 2020; Bányai et al., 2017). In this study, we provide an overview of influential factors in the problematic use of social media during this difficult time and hypothesize that loneliness, boredom and information anxiety may lead to problematic use of social media during a health crisis. In the next sections, we discuss our synthesis of the reviewed literature, present our theoretical framework and its corresponding set of hypotheses. Also, we discuss our methodology, the results of our analysis and conclude with limitations and recommendations.

2. Related Literature and Theoretical Foundations

At the start of 2020, information of the coronavirus disease (COVID-19) quickly circulated on social media sowing panic and fear among people (Ahmad & Murad, 2020). Moreover, with the imposition of quarantines and lockdowns, people spend more time on social media use, exposing themselves with unvetted information about COVID-19. In this research, we describe problematic use of social media as its excessive use, consuming time and resources impairing psychological health as well as the well-being of an individual (Andreasen & Pallesen, 2014). In the study of Shensa et al. (2017), the prevalence of problematic social media use appears to be strongly associated with increased depressive symptoms among young adults in the USA. The increase of depressive symptoms is closely related to the frequency of social media use, suggesting that the way we use social media poses a risk (Liu, Ming, Yi, Wang, & Yao, 2016), especially during a crisis (Rajkumar, 2020). In another cross-sectional study investigating maladaptive behaviors on social media among older adults in the United States, revealed
that higher perceived self-isolation is closely associated with the problematic use of social media (Meshi, Cotten, & Bender, 2020).

Social media has become the public source of shared and published information while the rest of the population is experiencing isolation during lockdowns and hospitalization amid the pandemic crisis. The study of Ahmad & Murad (2020) revealed that people are using social media information about COVID-19, and the nature of its impact varies among individual’s age, gender, and level of education. However, researchers argue that social media has played a vital role in escalating anxiety about the said outbreak. During the pandemic or public health crises, limited studies have investigated the social media’s role in increasing individuals’ anxieties and the relationship towards problematic social media use. A paper by a group of medical practitioners (Király et al., 2020) suggests that vulnerable individuals are at risk of developing uncontrolled usage patterns. These at-risk groups of individuals reported low self-esteem, high levels of depression symptoms, and elevated social media use (Bányai et al., 2017). Uncontrolled use of any technology generates noticeable distress that may impair personal, social and other important areas of functioning (Rumpf et al., 2018). The role of social ties in the propagation of information (Tran & Lee, 2016) and the exaggeration of discussions on unverified information on social media raises fear from the outbreak (Ahmed, Bath, Sbaffi, & Demartini, 2018). Garfin, Silver, and Holman (2020) highlighted that too much exposure of individuals to any crisis-related information amplifies public health consequences such as the cases of H1N1 (Taha, Matheson, & Anisman, 2014) and Ebola outbreaks (Thompson, Garfin, Holman, & Silver, 2017).

Moreover, in this pandemic, the public has been asked to follow social distancing guidelines and self-isolation. Although following to the advice is necessary in the present crisis, staying at home with limited social contact can have a significant effect on an individual’s mental well-being and, in particular, feelings of loneliness. Limiting social interaction is likely to affect the mood if individuals who failed to maintain that connection consciously by other means. Evidence suggests that individuals who feel lonely dwell too much time using the internet to alleviate their Loneliness (Kim, Larose, & Peng, 2009). However, loneliness is usually associated with the development of problematic use of social media since they developed uncontrolled patterns of self-regulation and control. (Skues, Williams, Oldmeadow, & Wise, 2016). As such, we hypothesized:

H1: Loneliness positively influence problematic use of social media

Based on Flow theory (Csikszentmihalyi, 1991, 2002), boredom is a context-specific experience which is dependent upon an activity and its corresponding environmental factors. It occurs when an individual fails to perceive a sense of flow and feels indifferent and uninterested in the engaged activity during free time. Individuals are likely to experience boredom when they cannot reorganize their time to engage in more exciting activities (Barnett & Klitzing, 2006). However, boredom can be eased by seeking stimulation that raises incitement, therefore, one approach to dealing with boredom is to engage in activities using networked mobile devices (Skues et al., 2016; Wang, 2019). Several studies found boredom to be significantly related with problems of negative effect on behavior, social relationships, and employment. In addition, boredom can be a common trigger for excessive internet use (Li, O’Brien, Snyder, & Howard, 2015) and can result in particularly problematic internet use behavior (Skues et al., 2016; Wang, 2019). Studies found that boredom is also associated with internet addiction (Nichols & Nicki, 2004), particularly, in social media (Pempek, Yermolayeva, & Calvert, 2009) and gaming applications (Rooij, Ferguson, Mheen, & Schoenmakers, 2017). As such, we hypothesized:

H2: Boredom positively influence problematic use of social media

Information anxiety represents a state when an individual’s effectiveness and efficiency in using information impeded by the amount of pertinent and potentially useful information available to them (Bawden & Robinson, 2008). It may refer to individual’s negative experience typified by their inability to access, understand, organize, or make use of information in any setting at their disposal (Ojo, 2016). Wurman (1989) argued that information anxiety occurs when information doesn’t give an individual enough understanding (Wurman, 1989, p. 34; Wurman, Leifer, Sume and Whitehouse, 2001, p.14). He noted that the uncertainty of information is a major cause of information anxiety. According to him,
information anxiety includes five components, namely: a) information understanding; b) information overload; c) the existence of the information; d) finding information; and e) accessing information. Since social media could be a source of information shared by different sources, any individual who cannot assess the veracity of information might cause them with information anxiety. As such, we hypothesized:

H3: Information anxiety positively influence problematic use of social media

In the context of this study, we hypothesize that Loneliness, Boredom and Information Anxiety are psychological determinants in the problematic use of social media as summarized in Figure 1 – Theoretical Framework:

3. Methods and Procedures

Items for each variable of the conceptual framework were adapted from past literature. The lone dependent variable, problematic use of social media, is represented in the instrument by items from Bergen Facebook Addiction Scale (BFAS) which captures the six dimensions of addiction namely (1) conflict, (2) salience, (3) mood, (4) withdrawal, (5) relapse and (6) modification (Andreassen, Torbjørn, Brunborg, & Pallesen, 2012). On the other hand, the three independent variables are represented in the instrument by items from various studies. There are three questions from the simplified loneliness scale by Hughes et al. (2004), eight questions from the information anxiety study of Girard and Allison (2015) and eight questions from the short boredom proneness scale of Struk, Carriere, Cheyne, & Danckert (2017). All items used a 5-point likert scale.

Considering the research locale and adaptation of items from different disciplines, testing for reliability and convergent validity is essential to establish instrument precision. A pilot test was conducted online with thirty-four (34) participants and responses were analyzed using SmartPLS. This study extracted the Cronbach Alpha and Composite Reliability for reliability as well Average Variance Extracted or AVE for convergent validity using a Partial Least Square or PLS algorithm. This process was repeated in several iterations after removing items until values of 0.70 for reliability and 0.50 for convergent validity was above the minimum values (J. Hair, Hult, Ringle, & Sarstedt, 2014; Nelson, Verhagen, & Noordzij, 2016). After the pilot test, 23 items were retained in the final model. In addition, this study checked for multicollinearity by examining the variance inflation factor or VIF on the independent variables. All values are below 3.3 indicating low collinearity among the predictor variables (Kock, 2015; Ramirez-Correa, 2017). In summary, it can be inferred that the instrument demonstrates reliability, validity and free from collinearity issues as shown in Table 1 – Variable Coefficients after Instrument Validation.
Table 1. Variable Coefficients after Instrument Validation

<table>
<thead>
<tr>
<th>Variable</th>
<th>VIF</th>
<th>α</th>
<th>CR</th>
<th>AVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loneliness</td>
<td>1.143</td>
<td>0.907</td>
<td>0.912</td>
<td>0.778</td>
</tr>
<tr>
<td>Boredom</td>
<td>1.395</td>
<td>0.873</td>
<td>0.890</td>
<td>0.540</td>
</tr>
<tr>
<td>Information Anxiety</td>
<td>1.358</td>
<td>0.710</td>
<td>0.873</td>
<td>0.775</td>
</tr>
<tr>
<td>Problematic Media Use n/a</td>
<td>0.906</td>
<td>0.921</td>
<td>0.516</td>
<td></td>
</tr>
</tbody>
</table>

VIF – Variance Inflation Factor (collinearity), α – Cronbach Alpha (reliability), CR – Composite Reliability (reliability), AVE – Average Variance Extracted (convergent validity)

4. Results and Discussions

A total of two hundred fifty-seven (257) social media users participated in this study and 56.3% are male while 43.7% are female. The minimum age is 18 years old and the maximum is 64 years old. The median age for the group is 34 years old. To test our proposed hypotheses in the operationalized framework, we performed a bootstrapping technique to verify the significance of the relationships between the dependent variables and the independent variables. Given the predictive perspective of the authors in presenting their hypotheses and the small sample size, the application of Partial Least Squares – Structural Equation Model through bootstrapping is justified (Hair, Hult, Ringle, & Sarstedt, 2014; Joe Hair, Hollingsworth, Randolph, & Chong, 2017).

Subscribing to the statistical procedures proposed by Hair et al. (2014), the authors tested the relationships in the structural model using the nonparametric bootstrap analysis to acquire the t-values as shown in Table 2 – Structural Model Coefficients. Both boredom and information anxiety are both positively related to the problematic use of social media as their coefficients are above the minimum 1.96 to establish significant relationships resulting in the acceptance of H2 and H3. The value of 3.047 for information anxiety has the strongest effect on the proposed predictors of problematic use of social media. Another factor that can contribute to the problematic use of social media is boredom with a path coefficient value of 2.048. While both information anxiety and boredom have positive relationships with the problematic use of social media, the same conclusion cannot be inferred with loneliness as its coefficient is 0.134 and therefore H1 is rejected in the context of this study.

Table 2. Structural Model Test Results

<table>
<thead>
<tr>
<th>HYPOTHESIS</th>
<th>SD</th>
<th>T STATISTICS</th>
<th>P Values</th>
<th>DECISION</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1: Loneliness positively influence problematic use of social media</td>
<td>0.116</td>
<td>0.134</td>
<td>0.894</td>
<td>Reject</td>
</tr>
<tr>
<td>H2: Boredom positively influence problematic use of social media</td>
<td>0.145</td>
<td>2.048</td>
<td>0.041</td>
<td>Accept</td>
</tr>
<tr>
<td>H3: Information anxiety positively influence problematic use of social media</td>
<td>0.119</td>
<td>3.047</td>
<td>0.002</td>
<td>Accept</td>
</tr>
</tbody>
</table>

The COVID-19 pandemic has created educational disruptions globally, forcing policymakers to shift to technology to ensure learning continuity (United Nations, 2020). However, with the use of ICT for online learning at home, individuals are usually confronted with various distractions, including the frequent use of social media that linked them to different unfruitful channels inhibiting their learning engagement and focus (Knowles & Dixon, 2016). Individuals failing to self-regulate their behavior with the said distractions are vulnerable to psychological disorder (Shensa et al., 2017), especially at this pandemic, when people may experience loneliness, boredom, and anxiety. While prior and related literature confirmed loneliness to be highly influential in the problematic use of social media (Ceyhan & Ceyhan, 2008), this cannot be proven in the context of this study as indicated in the T-statistics value of 0.134 for H1. This finding supports that the majority of Filipinos (65%) reported that they are less
likely to be lonely most of the time (Martha Jean Sanchez, 2020) since Filipinos are regarded as social people and also known for close family ties (Reyes, 2015). Filipinos’ characteristics may explain the findings from the United Nations Happiness Report reported that Filipinos ranked notably higher in the 2019 World Happiness Report compared to other emerging economies in Southeast Asia (Helliwell, Layard, & Sachs, 2019). This is also supported by a separate study of Porio & See (2017), which revealed that 72% of Filipinos reported being happy with only a small fraction (6%) reported being unhappy. This current study emphasized that despite the hardships brought by pandemic, Filipinos in general, despite usual exposures from the natural calamities and socio-economic struggles, remain to be resilient, hopeful and supportive (Porio & See, 2017).

Filipinos regularly use social technologies to connect with their loved ones and friends. This made the country lead in terms of time spent and social media usage even before the global pandemic (We Are Social, 2018). Moreover, the country’s imposition of longer and stringent quarantines has contributed to the extended use of Filipinos of social media sites (Li et al., 2015). Various restrictions of outdoor activities during quarantine caused a lot of boredom among Filipinos that triggered the desire to use social media platforms (Skues et al., 2016). However, the study of Stockdale & Coyne (2020) revealed that the more prolonged use of technology to alleviate boredom might expose individuals with the risk of developing problematic outcomes and patterns of behavior in using technology. The extensive use of these social media platforms during the pandemic to relieve boredom may lead to an unconscious habit of unregulated technology use (Skues et al., 2016). This study supports previous literature on the association between boredom and problematic use of social media (H2) and suggests that Filipinos who are prone to boredom are more likely to experience difficulty in disengaging with the social media platforms, pre-occupied with the technology, interference with other aspects of their lives, and problems controlling their social media use (Li et al., 2015; Pempek et al., 2009; Skues et al., 2016; Stockdale & Coyne, 2020). However, eliminating technological distractions would be impractical as a preventative strategy considering that the internet and social media platforms are crucial for Filipinos, especially during this pandemic. Many researchers argued on the exploration of various interventions and self-regulation mechanisms that influence the relationship between boredom and problematic use of social media (Skues et al., 2016).

Due to recent movements in the Philippine media and broadcasting industry, following the closure of the biggest TV network, social media offers Filipinos an alternative channel to access news and up-to-date information. Social media provides a continuous flow of rapidly evolving information from around the globe during this health crisis. However, social media, as a platform for social interaction, are filled with opinions and information that may or may not be accurate. The persistent flood of information makes it challenging to differentiate between reliable and useful, sensationalized, biases, or deliberately false news. The onset of a new pandemic for which Filipinos had no prior experience dealing with has caused fears among the general population, especially with the constant stream of news reports and information about an outbreak that causes anyone to feel anxious or distressed. In the Philippines, the National Center for Mental Health (NCMH) recorded a spike in the number of Filipinos having anxiety and depression during this pandemic. Our findings supported the relationship between information anxiety and the problematic use of social media (H3). This is consistent with the study of Garfin, Silver, & Holman (2020) that constant media exposure causes negative mental health effects. During this time of uncertainty and crisis, Filipinos increase reliance on media to make informed decisions regarding health-related measures as the government continuously change policies and guidelines in addressing the pandemic crisis. However, the information should be effectively communicated so as not to create ambiguity leading to heightened appraisals of threat, such as in the context of the H1N1 crisis, when increased uncertainty and uncontrollability amplifies anxiety (Taha et al., 2014). The World Health Organization (WHO, 2020) provided communications in support of mental health and psychosocial well-being during the COVID-19 outbreak. The guidelines highlighted the need to seek information only from trusted sources at a scheduled interval since the rapid constant stream of
information about the outbreak could cause anyone to feel anxious and worried.

5. Conclusion and Recommendations

This study used empirical evidence from an online survey to investigate how psychological factors influence the problematic use of social media during the COVID-19 pandemic. Our results indicate that boredom and information anxiety relate positively to the problematic use of social media following the Filipinos’ reliance on socially enabled technologies to make informed health-protective decisions and to connect to family and friends in a time where physical and social interactions are significantly reduced. On the contrary, the Filipinos’ happy and resilient nature reflects how loneliness did not influence the problematic use of social media platforms during a worldwide health crisis. This finding may be limited to this specific culture and future studies may investigate whether this is true in other contexts. In addition, further studies could be done to explore intervention and self-regulation strategies that would reduce the problematic use of social media amongst individuals. It is also recommended that this study is replicated with a larger sample size to increase its generalizability. Lastly, future research may consider qualitative interviews, content analysis, or social media analytics approaches to discover individual experiences and strategies in dealing with information anxiety concerning the use of social media platforms.

In the fight against this pandemic, social media platforms play a critical role in the way important information about COVID-19 is presented. Informally educating the general public about a health crisis through social media was found to be effective but challenges exist (Civelek, Cemberci, & Eralp, 2016). To maximize its potential, stakeholders must present verified information concisely to deter information anxiety (Malecki, Keating, & Safdar, 2020). Interactive presentation of information and the use of rich media can induce a form of enjoyment and therefore counter boredom. Infographics can be well understood by the general public and can present the substance of the message effectively and rapidly across different social media platforms (Chan, Nickson, Rudolph, Lee, & Joynt, 2020). Keeping these findings in mind, we urge individuals and public health officials to exercise good judgment when using social media particularly with respect to receiving and providing effective communication during a public health crisis.

References


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Investigating the Use of Prompts by a Robot Peer Tutor during Mathematics Problem Solving

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Abstract: Children as early as Grade 1 are taught how to solve simple mathematics word problems using a teacher-prescribed set of procedures. Drills are given to develop skills, but these exercises are often done in isolation inside the classroom or at home. The lack of interaction with peers can cause learners to be disinterested in completing the tasks that they may find meaningless, which may lead to the non-acquisition of the target skills. Learning with peers encourages the sharing and exchange of ideas in formulating solutions for the given problem. In this paper, we investigated the use of a social robot that can serve as a peer-tutor for Grade 1 students as they solve mathematics word problems. We observed how the robot facilitates the learning session through simple prompts anchored on the mathematical thinking process to guide children in understanding the problem and formulating a solution. Preliminary results in conducting a usability study with 12 children aged 6-8 years old showed that the robot’s inability to carry on a smooth conversation caused difficulty during the learning sessions. Children also felt pressured with the continuous questioning which is a necessary component of the mathematical thinking process.

Keywords: mathematics problem solving, peer tutor, child-robot interaction

1. Introduction

Problem solving refers to the “process of translating words into a mathematical expression and then solving the problem” (Barwell, 2011). It is a crucial component of the grade school curriculum to develop not only the learner’s skills in performing mathematical operations, but also in understanding the word problem in order to arrive at a solution (Pehkonen et al., 2013). In his classic book “How To Solve It”, Polya (1957) identified four basic principles of problem solving which serve as the backbone in the teaching of mathematics across different levels of education: understand the problem, devise a plan, carry out the plan, and look back. Learners, however, often describe problem solving as a boring and difficult task, mainly due to their inability to grasp the relevance of math concepts and operations to their daily life (Colgan, 2014).

Social interaction through peer-to-peer conversation has been shown to help children learn mathematics by offering opportunities for the joint construction of solutions (Mercer & Sams, 2006; Sfard & Kieran, 2001). Social support facilitates a collaborative learning environment where meaningful learning activities can be conducted (Michaelis & Mutlu, 2019). However, because young children lack the experience to maximize the benefits that can be gained from peer learning, classroom instructors often guide the proper use of language as a tool for reasoning and co-creation of knowledge among peers (Mercer & Sams, 2006).

Despite the presence of numerous studies that have reported the benefits of student-teacher and teacher-teacher interactions in enhancing learning, large class sizes and take-home assignments reduce the opportunities of providing the support needed by learners. This is where technology can come into play. Intelligent software agents can facilitate social learning activities in order to pique students’ interest and build positive attitude towards mathematics (Kim et al., 2007). These intelligent agents can be embedded in robots and be given abilities to interact with people and participate in their daily activities, including learning. Findings from various studies (Guthrie & Klauda, 2012; Michaelis &
Mutlu, 2019; Shiomi et al., 2015) suggest a social robot’s potential role in providing scaffolding to address disinterest in reading science textbooks among students. The study of (Liles et al., 2017) reported that children prefer working with a social robot over a workbook. Other studies indicated similar findings where robots have helped increase learning performance (Belpaeme et al., 2018; Tanaka & Matsuzoe, 2012).

As learning companions, social robots can take on varying roles such as a tutor or a peer (van Ewijk et al., 2020). As tutors, they can be experts who possess sufficient knowledge to deliver the lessons, and mentors who give guidance and advice to students (Baylor & Kim, 2005). As peers, they keep the student company, can provide encouragement and information, and may engage in collaborative and competitive behavior in the conduct of learning activities (Chou et al., 2003). These roles balance the characteristics that learners value in good human teachers - a tutor with expertise and knowledge in the subject domain; and a peer who is friendly, kind and enthusiastic.

This study is a preliminary investigation on the use of a social robot, Vi, as a peer-tutor. Vi employs a conversation flow that is anchored on mathematical thinking to guide Grade 1 students as they solve word problems involving addition and subtraction operations. In Section 2, we give an overview of related studies on the use of robots in learning and the mathematical thinking process that guides the generation of questions and prompts. We then describe the design of the conversation flow used by our robot peer-tutor to interact with learners during a problem solving session. In Section 4, we present our results in conducting a usability study with 12 students. We end our paper with a discussion of our findings and recommendations for further work.

2. Related Studies

Temming’s (2019) survey of different educational robots found varying motivations for their use, including one-on-one instruction in large size classrooms and learning companions for home-schooled children. The study of (Kanda et al., 2004) examined how children learn from robots the way they learn from other children. They found that the robots are more successful in establishing influence when the children have some initial proficiency or interest in the subject matter. On the other hand, Michaelis and Mutlu (2018) reported the use of an inexpressive text-to-speech engine inhibit the robot’s ability to provide socially meaningful interactions. Other studies have also looked into tailoring the robot’s responses according to the needs of individual learners (Ramachandran et al., 2017), tracking students’ academic performance, and monitoring student’s affective responses to maximize learning gains (Gordon et al., 2016).

Our work leverages on the use of mathematical thinking as an approach for children to solve word problems in math. Furthermore, to capture student interest, story-based word problems can be used to enable students to grasp the relevance of mathematics concepts and their application in real-life situations (Kilic & Sancar-Tokmak, 2017). The story-based problem can contain three parts comprising of the scenario, information and question (Barwell, 2011). Limjap (2011) explored the mathematical thinking process of schoolchildren in solving different types of story-based word problems. She found that even without formal instruction, children can act out a story problem, model it, and use counting strategies. To support the thinking process, teachers pose well-constructed problems and utilize scaffolding strategies to encourage learners to generate their own problem-solving procedures (Lawson, 2007; Suurtamm et al., 2015).

A given mathematics problem is then solved following four phases that mirror Polya’s principles (1957): understanding the problem situation by determining facts and the intended goal, devising a plan by expressing the problem as a mathematics expression, carrying out the plan by performing the mathematics operations, and looking back to assess and interpret the solution and results (Barwell, 2011; Cathcart et al., 2014). As part of the mathematical thinking process, learners can use drawings and real-world objects, such as papers, linking cubes and counters, to help them construct mathematical models of the given problem (Suurtamm et al., 2015).

Throughout the process, proper questioning is applied to probe learners to explain their mathematical thinking (Suurtamm et al., 2015). Questions include seeking an alternative method to
solve a problem, posing new challenges on the next task to be performed (e.g., “What should we do next?”), promoting group interaction through sharing ideas and strategies (e.g., “Can you explain this to me?”), and encouraging sense-making (e.g., “What did you find out when you did that?”). These can be used to facilitate discussions during peer learning. Way (2011) categorized these questions into: starter questions that focus children’s thinking in a general direction; mathematical thinking questions that focus learners on particular strategies and help them see patterns and relationships; assessment questions that ask learners to explain what they are doing or how they arrived at a solution; and final discussion questions to support learners in sharing and comparing strategies and solutions, and in reflecting and evaluating their work.

3. Prompt Generation

We designed a conversational model for Vi that considers the mathematical thinking process described in (Boonen et al., 2016; Limjap, 2011). It follows a three-stage dialogue flow, shown in Figure 1, to guide a learner through problem understanding, solution formulation, and object counting.

![Figure 1. Vi’s conversational model to support the mathematical thinking process.](image)

Understanding the problem uses starter questions to direct the learner’s attention to the given word problem. It entails asking the learner to articulate the problem using his/her own words and to enumerate what is being asked. While Vi does not provide scaffolding to help students arrive at the correct answer, it poses a series of prompts to ask for specific information described in the problem text, such as “Who bought an object?” and “How many objects did person buy?”. This line of questions, as illustrated in Figure 2, allows Vi to help learners see the patterns and relationships of entities (story characters and objects) in the given problem. Being able to identify the objects can translate to identifying the operands and the intended operations. Formulating a solution uses assessment questions to ask the learner to explain and to justify his/her approach in arriving at a solution. In the final phase, discussion questions, such as “How did you get the answer?”, are used to ask the learner to illustrate, through counting the objects strategy, how he/she derived the answer.

![Figure 2. Detailed conversation flow used to help learners understand the problem.](image)

A learner's answer to Vi’s prompts is categorized into two types: formative answers to starter, assessment and discussion questions; and final answer which corresponds to the given mathematics problem itself. Vi utilizes a set of dialogue moves to formulate a corresponding response. These moves are patterned after AutoTutor (Person et al., 2001) and include:

- Positive and negative feedback for correct and incorrect answers, respectively;
- Prompt to ask for information (“Who bought pencils?”) or to instruct the learner to perform an action (“Can you count how many pencils Rick has?”);
- *Pump* to elicit for more information when the learner gives an incomplete formative answer (“Who else bought pencils?”);
- *Hint* to repeat a portion of the problem again and to suggest a related course of action (“Rick has 9 pencils. Try counting the pencils Rick has.”);
- Re-question (“Can you tell me the names of the people who bought pencils?”); and
- *Summary* of the problem, including the operands, operation and final answer.

Three types of word problems that focus on whole numbers, and addition and subtraction operations are generated: *join-result unknown*, *separate change unknown*, and *compare where quantity is unknown*. These are based on the learning competencies in mathematics prescribed by the Department of Education for Grade 1 learners (Limjap, 2011). Examples are shown in Table 1.

### Table 1. Three types of word problems given to learners.

<table>
<thead>
<tr>
<th>Type of Problem</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Join-Result Unknown</td>
<td>Bob and Nicole went to a music store. Bob bought (operand 1) violins while Nicole bought (operand 2) trumpets on display. How many instruments did both of them buy in total?</td>
</tr>
<tr>
<td>Separate Change Unknown</td>
<td>Helen has (operand 1) candies. She gave Jake some candies. Now, she has (operand 2) candies left. How many candies did Helen give to Jake?</td>
</tr>
<tr>
<td>Compare</td>
<td>Joey has (operand 1) medals. Rachel has (operand 2) more medals than Joey. How many medals does Rachel have?</td>
</tr>
</tbody>
</table>

To support the counting strategy employed in the mathematical thinking process, a laptop is used to host a software application that provides the visual representation of the objects described in the word problem. As shown in Figure 3, this setup can afford opportunities for both visual and auditory learners to interact with Vi. The dialogue is recorded through the chat log found on the left side of the user interface. Listing 1 shows a sample chat log.

**Figure 3.** Software interface as a visual representation of the objects described in the word problem, to support the counting strategy included in the mathematical thinking process.

**Listing 1. Excerpt of conversation log of S4 to illustrate how Vi formulates prompts to guide learners while probing them to explain their mathematical thinking.**

[1] VI That’s great! Here’s a problem for you.
   Bob and Nicole went to a music store. Bob bought 4 violins while Nicole bought 8 trumpets on display. What are the names of the people who bought instruments?

[2] S4 Bob and Nicole

[3] VI That’s correct! Bob and Nicole bought instruments. Can you count the number of violins Bob bought?
There are four violins.

There are eight trumpets.

In total there are 12.

I add.

Vi is developed on top of the NEC PaPeRo (Partner-type Personal Robot) robotic platform, shown in Figure 4. To mimic non-verbal cues as a means of providing unobtrusive feedback during the robot-learner interaction, built-in physical facilities of PaPeRo were utilized. These include the LEDs found in the robot’s ears, mouth and cheeks, as well as body movements through nodding and shaking of the robot’s head. PaPeRo can only recognize speech in the Japanese language. We used Google’s Cloud Speech API to allow Vi to recognize speech in the English language.

Figure 4. Built-in physical facilities of NEC PaPeRo (adapted from https://www.necplatforms.co.jp/solution/papero_i/index.html).

4. Validation

Twelve (12) Grade 1 students, equally divided into having an above average, average or below average academic performance in math, were selected to participate in the study. All students are from the same school. The experiment procedure and research instruments were sent to the school principal prior to the commencement of the validation: (i) the Informed Consent Form that prescribes ethics statements on anonymity, aggregation of the collected data to produce the research report, voluntary participation and option to withdraw from the study; (ii) the Informed Assent Form that gives minors the chance to make their own decision about their participation; (iii) the set of preliminary interview questions to collect profile information about the learners (see Table 2); (iv) the Observation Checklist for recording issues that may arise during the experiments; and (v) the Feedback Form for learners to rate their interaction with Vi using a 5-point Likert scale.

Table 2. Preliminary interview questions to collect the profile of the participants.

<table>
<thead>
<tr>
<th></th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Do you like Math? Why or why not?</td>
</tr>
<tr>
<td>2</td>
<td>Do you like interacting or playing with robots?</td>
</tr>
<tr>
<td>3</td>
<td>What do you think about robots?</td>
</tr>
<tr>
<td>4</td>
<td>How do you learn Math?</td>
</tr>
<tr>
<td>5</td>
<td>Where/How often do you speak English every day?</td>
</tr>
<tr>
<td>6</td>
<td>With whom do you speak English?</td>
</tr>
</tbody>
</table>
Each learner is given two chances to answer each type of the story-based mathematics problem; should the learner get the correct answer on the first try, Vi proceeds to the next type of problem. Based on the number of tries or mistakes, learners are then classified as expert, intermediate or novice (Limjap, 2011). An expert is able to correctly solve the 3 types of problems; an intermediate learner makes mistakes in solving one of the problem types; and a novice makes at least 2 mistakes. Furthermore, because mathematical thinking process allows learners to utilize various tools during problem solving, including the use of their fingers and physical objects around them as a form of counting strategies (Artut, 2015), we provided our participants with external resources, i.e., paper and pencil, to enable them to do manual-based solution (if they want to) as a supplement to the visual animation in the software interface.

4.1 Learning with Vi

Table 3 lists the student profile vis-à-vis their performance in doing the learning task with Vi. All learners are 6 years old, except for S12 who is 8 years old. Two learners, S2 and S3, were not able to complete their session due to technical challenges in communicating with the peer-tutor.

Table 3. Student profile vis-à-vis performance in the learning task with Vi. (AcadPerf – academic performance in mathematics where AA – above average, A – average and BA – below average; JRU – joint result unknown, SCU – separate change unknown, C – compare; LearnType – learner type based on number of mistakes committed in solving mathematics word problems with Vi)

<table>
<thead>
<tr>
<th>S</th>
<th>Acad Perf</th>
<th>Perception on robots</th>
<th>How they learn Math</th>
<th>Number of Tries</th>
<th>Learn Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>JRU</td>
<td>SCU</td>
</tr>
<tr>
<td>S1</td>
<td>AA</td>
<td>Enjoys robots</td>
<td>Books, studies at home</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>S2</td>
<td>A</td>
<td>Familiar with Alexa</td>
<td>-</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>S3</td>
<td>BA</td>
<td>Scared of robots</td>
<td>-</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>S4</td>
<td>AA</td>
<td>Robots are cool</td>
<td>Practices at home &amp; school</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>S5</td>
<td>A</td>
<td>Can play with it</td>
<td>Reads books</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>S6</td>
<td>BA</td>
<td>Can play with it</td>
<td>Learns from father</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>S7</td>
<td>AA</td>
<td>-</td>
<td>Studies &amp; practices at home</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>S8</td>
<td>A</td>
<td>They have eyes</td>
<td>Studies at home</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>S9</td>
<td>BA</td>
<td>Robots are smart</td>
<td>Learns at school</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>S10</td>
<td>AA</td>
<td>You can ask questions</td>
<td>Reads mathematics book</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>S11</td>
<td>A</td>
<td>Good</td>
<td>Attended Kumon</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>S12</td>
<td>BA</td>
<td>Happy to play with</td>
<td>Using fingers and sticks</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

As can be seen from the table, our preliminary results show no evident correlation between the academic performance and the learner type. Three learners that were classified by Vi as expert - S4, S5 and S12 - have above average, average and below average academic performance in math, respectively. The other three above average students - S1, S7 and S10 - committed a mistake each, either in the separate change unknown problem (subtraction) or in the compare problem (addition). A sample chat log where S1 committed a mistake in solving the compare problem is shown in Listing 2.

To better understand the experience of the 12 participants, we asked them to share their feedback in learning with Vi using a 5-point Likert scale. The results are shown in Table 4. S1 and S12 reported that it was not easy for them to talk to the peer-tutor. Part of the problem can be attributed to errors committed by the speech recognition module in processing user inputs. All students had to repeat their answers at least once when prompted by Vi with “Can you say that again?”. This occurs when the robot’s speech recognition fails to properly detect the numeric input, e.g., 5 as “fight” and 9 as “lion” or “mayan”. It was observed that this inability to carry on a smooth conversation with the peer-tutor led
to mistakes in solving problems, e.g., S1 who is an above average student had difficulty solving the compare problem, and the non-enjoyment of the learning task.

Table 4. Results of feedback from learners on their experience in learning with Vi.

<table>
<thead>
<tr>
<th>Survey Item</th>
<th>Above Ave.</th>
<th>Average</th>
<th>Below Ave.</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>I find Vi easy to talk to.</td>
<td>3.50</td>
<td>4.00</td>
<td>3.75</td>
<td>3.75</td>
</tr>
<tr>
<td>I can understand Vi’s questions.</td>
<td>4.25</td>
<td>3.50</td>
<td>4.50</td>
<td>4.08</td>
</tr>
<tr>
<td>I am not pressured by Vi’s questions.</td>
<td>3.75</td>
<td>2.50</td>
<td>2.50</td>
<td>2.92</td>
</tr>
<tr>
<td>Vi’s questions helped me answer the problems.</td>
<td>4.75</td>
<td>5.00</td>
<td>3.75</td>
<td>4.50</td>
</tr>
<tr>
<td>I see Vi as someone I can learn from.</td>
<td>4.25</td>
<td>5.00</td>
<td>4.75</td>
<td>4.67</td>
</tr>
<tr>
<td>I would want to talk with Vi again.</td>
<td>4.50</td>
<td>4.75</td>
<td>4.50</td>
<td>4.58</td>
</tr>
</tbody>
</table>

Listing 2. Excerpt of conversation log of S1 where he/she committed a mistake in lines 6 and 10.

[1] VI  Here's the last type of problem.
        Joey has 7 medals. Rachel has 4 more medals than Joey.
        What are the names of the characters that have medals?

[2] S1  Joey and Rachel

[3] VI  You are right, Joey and Rachel have medals. Can you count the number of medals Joey has?

[4] S1  7

[5] VI  That’s right! Can you count how many medals Rachel has more than Joey?

[6] S1  7

[7] VI  I don’t think that’s right. Try again.

[8] S1  4

[9] VI  You are right. Joey has 7 medals. Rachel has 4 more medals than Joey.
        How many medals does Rachel have? You can work on the problem now.

[10] S1  4

[11] VI  How did you get the answer?

[12] S1  11

[13] VI  Here, let me help you. The correct answer is 11. Joey has 7 medals.
        Rachel has 4 more medals than Joey. 7 plus 4 is 11.

While participants understood Vi’s prompts and gave an average score of 4.08, half of them admitted feeling pressured by these questions, thus, the low average score of 2.92. This is evident with S10 who, despite being an above average student, had at one point covered his/her ears to avoid hearing the negative feedback from the peer-tutor. Moreover, despite embedding the mathematical concepts in the story to make the task more appealing, the scaffold needed to build the learner’s understanding necessitated a series of prompts that is repetitive. This is in contrast to the spontaneity and variety that characterize peer-to-peer conversations. Thus, S12 perceived the assessment and discussion questions as manifestations of Vi’s role as a tutor who probes their understanding of the word problem, rather than as a peer learning companion who co-constructs solutions with them.

Despite their negative perception of the tutor role, the participants acknowledged that Vi’s questions helped them answer the mathematics problems, with an average score of 4.50. They viewed the peer-tutor as someone they can learn from and are willing to work with Vi again. These results are supported by two (2) primary school mathematics educators who evaluated Vi. They found Vi’s prompts to be well-structured and encouraged collaborative learning to help the students comprehend the given problems. The also commended the timely generation of feedback as these allowed learners to immediately rethink their solutions in order to correct their answers.

The implicit guidance of approaching the problems through counting of the objects afforded learners with a mechanism to formulate their answers by employing the counting method. The facility to do visual counting through the software application interface shown in Figure 3 replaced the need for pen and paper, or other artifacts that children typically use in counting, e.g., physical objects or their
fingers (Artut, 2015; Limjap, 2011). Nevertheless, we saw one learner, S2, who used the pen and paper to perform the required task as seen in the picture of his/her scratch paper in Figure 5.

4.2 Challenges in Communication

To communicate with the learners, Vi uses a number of facilities which include speech recognition, speech synthesis, physical cues and visual display. We give an analysis on the support and challenges posed by these interfaces.

It was observed in all 12 sessions that Vi's speech recognition does not always capture the responses of the learners. This is particularly noticeable when Vi is conversing with learners who are reserved or have inaudible voices, prompting the learners to repeat their responses. A sample excerpt of a log where Vi had trouble understanding S10 is shown in Listing 3. As seen in lines 2, 4 and 6, S10 tried to answer, "Bob and Nicole". However, due to the inaudibility of L10's voice, Vi repeatedly misunderstood the responses as "Bob and Nico" and "Bob and Nick". To allow the session to proceed, the facilitator assisted the participant in responding to Vi as seen in line 6.

Listing 3. Excerpt of conversation log of S10 showing Vi’s incorrect speech recognition.

<table>
<thead>
<tr>
<th></th>
<th>VI</th>
<th>S10</th>
<th>VI</th>
<th>S10</th>
<th>VI</th>
<th>S10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VI</td>
<td>That's great! Here's a problem for you. Bob and Nicole went to a music store. Bob bought 2 violins while Nicole bought 6 trumpets on display. What are the names of the people who bought instruments?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>S10</td>
<td>Bob and Nico (phrase incorrectly recognized)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>VI</td>
<td>Say that one more time?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>S10</td>
<td>Bob and Nick (phrase incorrectly recognized)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>VI</td>
<td>Try again! Who are the people that bought instruments?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>S10</td>
<td>Bob and Nicole (phrase correctly recognized)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>VI</td>
<td>That's correct! Bob and Nicole bought instruments.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Problems such as the one shown in Listing 3 abound in all the conversation logs. In half of the cases, Vi had to restart the session, causing some participants (S2 and S3) to lose interest and discontinue the task. Breakdowns in communication due to challenges with speech recognition have also been reported as causing hindrance to collaborative storytelling (Ureta et al., 2020) and the robot’s ability to provide socially meaningful interactions (Michaelis & Mutlu, 2018). This is because existing speech recognition technologies perform poorly on children’s speech (Kennedy et al., 2017).

The employment of appropriate turn-taking strategies can also facilitate learning and interaction. This is evident in Vi’s allocation of sufficient time to wait for the learner’s response. While there is no limit to the time allocated for the learner to provide an answer, this sequence begins by
pressing a button on Vi’s base and ends by pressing the same button again. This became an impediment when coupled with the cognitive load of the problem being solved, as learners tend to forget pressing the button before and after giving their responses. Among the 12 learners, only S4, S5 and S6 were able to remember pressing the button to start and end the speech recognition service.

Another turn-taking strategy is seen in Vi’s use of PaPeRo’s built-in facilities in order to generate physical cues that signal the learner when to speak and when to listen. Vi’s mouth lights up when it is speaking, and its ears light up to let the child know that it is listening. However, there were still cases when the learners, S3 and S11 in particular, were unable to follow the instruction of when to listen to Vi. S3 tried to respond while Vi was speaking. S11, on the other hand, pressed the button to respond while Vi was still speaking. This is attributed to the unfamiliarity with the protocols of interacting with Vi, which were evident at the start of the interaction when the learners had no prior experience and lessened as they became more confident as the session progresses.

5. Conclusion and Further Work

The rising popularity of social robots in the field of education is mainly attributed to their potential in setting up a collaborative learning environment that supports social interaction between learner and robot. In this paper, we presented our robot peer-tutor, Vi that has been designed to supplement peer interaction by generating prompts anchored on mathematical thinking to guide Grade 1 students in solving story-based mathematics word problems. A range of physical facilities combined with visual and conversational interfaces reinforce the child-robot interaction.

Solving mathematics word problems requires not only the ability to apply mechanical skills but also the ability to comprehend the text (Boonen et al., 2016). The application of Polya’s (1957) problem solving principles in the design of Vi’s conversation flow enabled the peer-tutor to help learners work through the given mathematics word problems. This is evident in Vi’s use of a series of starter, assessment and discussion questions in order to help the learner identify the input, determine what is required, and formulate a solution plan to derive the answer. While accurate speech recognition presented one of the major challenges encountered during the validation process, the language proficiency of the learners also contributed to their inability to comprehend the given word problems. Future work can examine how learner’s language skills affect their ability to understand and subsequently solve the mathematics problems.

Further work in applying advanced natural language processing techniques can also benefit the child-robot interaction in multiple ways. Vi can formulate adaptive dialogue strategies that are spontaneous and add variety while scaffolding individual learners in comprehending the given word problems. The social robot can also generate prompts that consider the needs of individual learners based on their academic performance (Ramachandran et al., 2017), and monitor student’s affective responses to maximize learning gains (Gordon et al., 2016). Furthermore, the story word problems can be contextualized to the learner’s situational interest to influence attention and engagement with the task (Rembert et al., 2019). Lastly, Vi can facilitate a healthy discussion by accommodating questions from the students, thereby increasing the latter’s engagement in the learning process.

Our initial investigation shed insights on Vi’s potential benefits as a peer-tutor in learning mathematics problem solving during a single session. Longer validation needs to be conducted to assess how child-robot interaction in an educational context, particularly as a learning companion, can lead to improvement in learning gains beyond the classroom setting. Insights on the types and strengths of child-robot relationships that are formed from repeated and sustained interaction can also be revealed through these studies.

Acknowledgements

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References


Analysis of Learning Activities with Automated Auxiliary Problem Presentation for Breaking Learner Impasses in Physics Error-based Simulations

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Abstract: Error-based Simulation (EBS) is a framework that supports learning by visualizing errors. EBS systems generate and visualize simulations of assumed phenomena from learner answers. By letting the learner observe the results, the system shows how wrong answers result in wrong phenomena. The system thus supports trial-and-error processes until a correct response results in correct phenomena. EBS systems effectively support trial-and-error in learning of physical mechanics. Despite this, learners may become stuck because the EBS system does not provide the correct answers to problems. Stepwise presentation of auxiliary problems can be useful for resolving such impasses. Auxiliary problems are simplifications of the original problem containing fewer targeted learning concepts, a scaffolding approach leading toward the original problem. Therefore, we developed a learning support system that adaptively presents auxiliary problems by determining from error trends the concepts that the learner does not yet understand. We also evaluated the developed system through experimentation. Using system logs from those experiments, we analyzed in detail the learning activities related to the auxiliary problem presentation function in EBS. The results suggested that adaptively presenting auxiliary problems to learners can effectively resolve impasses.

Keywords: Auxiliary problem, Error-based Simulation, mechanics learning, system log analysis

1. Introduction

Learning support systems with Error-based Simulation (EBS) provide effective environments for learning physical mechanics. EBS is a framework that supports learning by visualizing errors (Hirashima, Horiguchi, Kashihara & Toyoda, 1998), which has been demonstrated as effective in learning domains such as mathematics (Kurokawa, Tomoto, Horiguchi & Hirashima, 2018), English writing (Kunichika, Takeuchi & Hirashima, 2003), and physics (Hirashima et al., 1998; Ueno, Tomoto, Horiguchi & Hirashima, 2019). EBS systems generate and visualize simulations of assumed phenomena from learner answers. By letting the learner observe the results, the system shows how wrong answers result in wrong phenomena. The system thus supports trial-and-error processes until a correct response results in correct phenomena.

EBS is also effective for learning physical mechanics. However, some factors in EBS learning can result in impasses. One such factor is that EBS does not present correct answers because the aim of EBS is to induce a trial-and-error process. Another factor is that in some cases it is difficult to visualize errors from simulations. In the case of two vertically stacked objects, for example, if learners input a gravity force and a normal force for each object, those forces will be in equilibrium in the simulation (Figure 1). In this case, the system cannot visualize the error of a deficiency of force from the upper object pushing on the lower object. To address this factor, Ueno et al. (2019) developed an EBS system that provides measurement tools for visualizing error in indiscernible parameters such as load and velocity.
However, if the learner does not notice any errors while observing the simulation, they may not be able to resolve the impasse even with such support. We therefore focused on the presentation of auxiliary problems as one method for resolving learner impasses (Hirashima, Kashihara & Toyoda, 1995). Auxiliary problems are simplified versions of the original problem. By presenting auxiliary problems, new scaffolds can be presented to learners who have failed to solve problems, it is expected that they will be able to find the correct solutions. The learning effect of presenting such auxiliary problems has already been confirmed in a problem exercise system that does not apply EBS (Hayashi, Shinohara, Yamamoto, Hayashi, Horiguchi & Hirashima, 2014).

We previously developed and evaluated an extension of the conventional EBS system. The extended EBS system can adaptively and automatically present auxiliary problems by diagnosing concepts that the learner does not understand, based on trends in incorrect learner responses (Aikawa, Koike & Tomoto, 2020a). We also improved and evaluated problem sequences in the system (Aikawa, Koike & Tomoto, 2020b).

In this study, we conducted additional experiments with our system (Aikawa et al., 2020b) and analyzed those learning activities. The resulting analysis of system logs indicated that learning activities with automated auxiliary problem presentation effectively resolved learner impasses in EBS.

2. Physics Error-based Simulation (Physics EBS)

A physics EBS system generates simulations of “assumed correct” phenomena based on learner answers (Hirashima et al., 1998), helping learners viewing the simulation to find errors. Learners can deepen their knowledge by noticing errors themselves, thereby obtaining learning effects.

A physics EBS system first presents a diagram of a certain phenomenon, and the learner is tasked with drawing arrows that indicate the forces acting on the objects in the diagram. Learner errors include drawing wrong forces or not drawing an existing force. From the learner input, the EBS system simulates strange behavior if the drawing is incorrect or natural behavior if the drawing is correct.

For example, Figure 2 shows examples of incorrect and correct user depictions of gravity and the normal force acting on a stationary object. If the learner enters only the gravity arrow as in Figure 2(a1), the EBS system presents a simulation in which the object falls through the floor at a constant acceleration because there is no force to counteract gravity, as in Figure 2(a2). Because this behavior is impossible in reality, the learner can see that their answer is wrong. The learner can then add an arrow to balance the gravity and the normal force, as in Figure 2(b1), thereby generating a simulation in which the object remains stationary on the floor. Such activities allow the learner to correctly understand the normal force, making an EBS system effective for learning physics (Hirashima, Imai, Horiguchi & Tomoto, 2009).

EBS systems simulate phenomena occurring when erroneous learner knowledge as demonstrated through answers is assumed correct, but these systems do not provide correct answers. Consequently, some learners reach an impasse.
3. Physics EBS with Automated Auxiliary Problem Presentation

(a) Problem presentation screen.

(b) Auxiliary problem presentation message.
We developed a system in which auxiliary problems are introduced into a conventional EBS to help learners resolve impasses in EBS problems. Simple auxiliary problem is presented to learners failing to provide a correct solution a predetermined number of times.

Our system uses answer histories to analyze causes of impasses, and then presents appropriate auxiliary problems. By correctly solving auxiliary problems, the learner gradually returns to the original problem. If the learner continues to make errors, the answer history is analyzed again, and the process shifts to another appropriate auxiliary problem. Learners can thus resolve impasses by themselves.

Figure 3 shows example screens in the developed system. The system first presents a problem like that shown in Figure 3(a). The learner answers the presented problem by drawing arrows on the input screen on the right side of Figure 3(a). If the learner makes an error five times, a message like that in Figure 3(b) appears, asking if the learner would like to attempt an auxiliary problem. If "Yes" is selected, the system presents an auxiliary problem like that shown in Figure 3(c). And if "No" is selected, the system presents the same problem repeatedly until 15 times. If it exceeds 15 times, the learner automatically shifts to the auxiliary problem.

Sequencing is important when presenting auxiliary problems. In particular, it is necessary to clarify differences between each problem and to adaptively sequence according to learner knowledge states. Therefore, we reconsidered problem sequencing based on the causal reasoning theory of force and motion by Mizoguchi et al. (2016) and implemented the results in a learning support system.

### 3.1 Design of Auxiliary Problems

![Figure 4. An original problem.](image)
The auxiliary problem for this system was created by referring to the causal reasoning theory of force and motion by Mizoguchi et al. (2016). Elementary mechanics in school education focuses on understanding phenomena using equations. However, the causal relationship cannot be understood by equations. For example, in Figure 4, (I) is generated first, and then (II) is generated by (I), but the equation does not know the order of generation of such forces, and the interpretation is entrusted to the learner. Causal understanding is the understanding of the order of force generation. By creating auxiliary problems based on causal reasoning theory, learners can learn in the easy-to-understand order. However, we carefully considered there to be no contradiction between the equational understanding and the causal understanding.

Figure 4 shows a problem (P1) originally presented in the system. In this problem, objects A and B are placed on a floor, object A is pushed from the side, and both objects slide from left to right under constant acceleration.

If this problem is interpreted using causal inference, gravity acts on the objects A and B, as indicated by arrows (I) and (II). The gravitational force of object B acts on object A, as indicated by arrow (II), and each of those forces act on the floor as indicated by arrow (2). As arrow (3) indicates, the normal force from the floor pushes back on object A, which in turn pushes back on object B, as indicated by arrow (4). Objects A and B remain stationary because of the vertical directions of these arrows. Also, object A tries to move left to right due to the external force F represented by arrow (i), with that force propagating to object B and the floor, as shown by arrows (ii) and (iii). As a result, a frictional force acts at each contact surface, as shown by arrows (iv) and (v). This problem depicts constant acceleration with no initial velocity, so movement results from an external force exceeding the frictional force, and a constant sideways force results in acceleration. Arrow (ii) indicates the resultant force, so objects A and B move at the same acceleration. From this, we created the simplified auxiliary problems shown in Figure 5.

Problem P6 is a simplified problem in which the vertical force in Problem P1 is easily learned. Without external force F, no sideways propagation of force occurs. This auxiliary problem thus allows learners to consider only vertical forces.
Problem P7 is simplified so that the force represented by arrow (II) in Problems P1 and P6 can be easily learned. In those problems, arrow (II) indicates propagation from gravity (arrow (I)) acting on object B. Therefore, to consider arrow (II), it is necessary to consider the propagation relation between (I) and (II). Therefore, by omitting the causal relationship between (I) and (II) and making the force (I) that causes (II) the external force F, the learner can easily recognize the force of (II).

Problem P2 is a simplified problem that makes it easier to learn the forces indicated by arrows (iv) and (v) in Problem P1 by omitting requirements for considering propagation of gravitational force from object B in the vertical direction.

Problem P3 removes the need to consider the relation between force (ii) and the frictional force (iv) generated by propagation from problem P2.

Problem P4 eliminates the frictional force from problem P3, removing the need to consider force (iii) and the resulting force (v).

Problem P5 removes the force on object A in problem P1, which generates force (ii) when the lower object A tries to move by force (i). In this problem, force (i) is directly generated by moving the floor with a belt conveyor.

Problem P8 is a simplified problem that eliminates forces received from above and lateral forces in all problems. This facilitates learning of gravity ((1) and (I)) and normal drag ((3) and (4)).
3.2 Problem Sequences and Presentation Method

Figure 5 shows the simplified problems described in section 3.1 as a sequencing diagram. This system first presents problem P1 and shifts to simpler problems according to the learner’s errors. The system first compares the learner’s answers with the correct answers to extract differing forces, which are considered to be misunderstood by the learner. Problem transitioning is based on these discovered differences. In this study, we first shift to the simplest problem, which involves the misunderstood force. As each problem is solved, the system gradually increases the difficulty based on edge relations.

For example, in problem P1, if the learner has not depicted the force (II) acting on the lower object from object B above, the system presents the simplest problem involving force (II), namely problem P7. In Problem P1, to guide force (II), it is necessary to understand that gravitational force (I) is generated in object B, and (II) is generated by the propagation of that force. Problem P7 is easier to understand because force (II) is directly generated by the external force. After problem P7 is solved, complexity increases in order of problem P6, then problem P1. If the frictional force (v) generated between the floor and object A is not described in Problem P1, the system presents Problem P3, which is the simplest problem involving force (v).

4. Evaluation

4.1 Method

We performed experiments to verify the learning effects from the automatically presented auxiliary problems in the developed EBS. Participants in each experiment were 13 engineering department university students who had studied elementary mechanics. Experiments comprised the following steps:

1. Pre-test (7 minutes)
2. System use (40 minutes)
3. Post-test (7 minutes)
4. Questionnaire

Before conducting the experiments, we sufficiently described the answering method and system operations. In step (2), we randomly assigned eight participants to an experimental group and five to a control group because they have each participated in other times and we could not compare the pre-test scores before their assignment. The experimental group used an EBS that automatically shifts to the auxiliary problem, whereas the control group used an EBS that allows learners to optionally select auxiliary problems. As mentioned in Chapter 3, the system asks if the learner would like to attempt an auxiliary problem if the learner makes an error five times. The learner has the option to shift up to 15 times, but after 15 times the shift is automatic. In EBS that automatically shifts to the auxiliary problem, the system automatically selects auxiliary problems that are adaptive to the cause of the learner's impasse. And in EBS that allows learners to optionally select auxiliary problems, a list of problems is displayed, and the learner selects an auxiliary problem from the list.

In steps (1) and (3), participants took a paper test in which they indicated forces acting on the presented phenomena as arrows. Both tests had seven problems.

4.2 Results

4.2.1 Tests and Questionnaires

<table>
<thead>
<tr>
<th></th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exp.</td>
<td>2.37</td>
<td>1.22</td>
<td>3.75</td>
</tr>
<tr>
<td>Ctrl.</td>
<td>2.40</td>
<td>0.49</td>
<td>3.40</td>
</tr>
</tbody>
</table>
All tests were scored as one point per correctly solved problem. Table 1 shows the means and standard deviations for pre- and post-tests.

Each mean score in Table 1 increased from the pre-test to the post-test. However, analysis of variance did not indicate a significant difference, suggesting no significant difference in learning effects.

Table 2 summarizes some of the results from the questionnaire, which used a six-level ranking from "very much" (6) to "very little" (1). We considered questionnaire item responses of 4 to 6 as positive, and responses of 1 to 3 as negative.

Table 2. Questionnaire Results

<table>
<thead>
<tr>
<th>Question</th>
<th>Exp.</th>
<th>Ctrl.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Do you think learning through this system will help you obtain correct answers?</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>(b) (Experimental group only) Do you think the simplified problems presented by the system were appropriate?</td>
<td>7</td>
<td>--</td>
</tr>
<tr>
<td>(c) (Control group only) Do you think the simplified problems you chose were appropriate?</td>
<td>--</td>
<td>4</td>
</tr>
<tr>
<td>(d) Do you think the simplified problems presented by the system advanced your learning?</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>(e) Do you think the simplified problems presented by the system led you to correct solutions of the original problem?</td>
<td>7</td>
<td>5</td>
</tr>
</tbody>
</table>

All five participants in the control group, which used a system allowing free selection of simplified problems, positively responded to question (a). Seven of eight participants in the experimental group, which responded to auxiliary problems presented by the system, responded positively whereas only one answered negatively. The participant who answered negatively are not the same person.

This experiment indicated learning effects for both the system used by the experimental group and that used by the control group, with positive results being obtained from nearly all questionnaire items. However, there was no significant difference between the control group and the experimental group in 2 (the group of experimental or control) x 2 (the timing of pre- and post-test) ANOVA. The questionnaire also suggested that the control group thought they could appropriately select simplified problems by themselves.

In this study, we considered that learners solving complex problems would have difficulty understanding what points were misunderstood and which auxiliary problems should be solved. However, we found that participants with sufficient ability grasped their own misunderstandings, and that when given a list of appropriately designed auxiliary problems, they could self-select appropriate problems. Furthermore, self-selection of problems may provide more information than the system does. The experimental group can see only limited auxiliary problems unless they make various mistakes. If there is only one pattern of mistakes, learners may see only one auxiliary problem. On the other hand, the control group can arbitrarily see all the auxiliary problems. The control group acquires a lot of information because many auxiliary problems can be seen. For example, in question (c), four out of five participants in the control group stated that they were able to select an appropriate question. This is likely one reason why testing indicated no significant difference. We, therefore, found that effective learning is possible for participants with high self-learning ability when they are presented with an appropriate collection of auxiliary problems and the EBS functions without
automated auxiliary problem presentations like the control group. In the future, it will be necessary to consider whether the participants in these experiments were appropriate as target users. In addition, the experimental group and the control group were randomly assigned, but the experiments will be conducted by assigning them evenly based on the scores of the pre-test from next time.

### 4.2.2 Analysis of Learning Activities

Table 3 shows the problem sequences and analysis results for problem transitions by 13 learners, designated as A through M. The "Detected cause of impasse" column shows the cause as determined by the system when the learner first attempted problem P1. In this system, the learner shifts to the auxiliary problem corresponding to the cause of the impasse after attempting the problem a certain number of times. "Number of problems shifts until solved cause of impasse" shows the number of shifts until arriving at a problem that suggests resolution of the cause of a detected impasse, and " (Total number)" is the total number of times the learner moved to the problem. "Exercise completed" shows whether the learner was able to correctly answer problem P1 within 40 min.

<table>
<thead>
<tr>
<th>Participants</th>
<th>Detected cause of impasse</th>
<th>Number of problems shifts until solved cause of impasse (Total number)</th>
<th>Problem shifts by learner (* resolved cause of impasse)</th>
<th>Exercise completed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experimental group</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>(ii)</td>
<td>1 (2)</td>
<td>P1 → P5* → P1</td>
<td>Yes</td>
</tr>
<tr>
<td>B</td>
<td>(iv)</td>
<td>1 (2)</td>
<td>P1 → P2* → P1</td>
<td>Yes</td>
</tr>
<tr>
<td>C</td>
<td>(v)</td>
<td>1 (8)</td>
<td>P1 → P3* → P2 → P1 → …</td>
<td>No</td>
</tr>
<tr>
<td>D</td>
<td>(II)</td>
<td>– (8)</td>
<td>P1 → P7 → P6 → P7 → P6 → …</td>
<td>No</td>
</tr>
<tr>
<td>E</td>
<td>(II)</td>
<td>2 (6)</td>
<td>P1 → P7 → P6* → P1 → …</td>
<td>Yes</td>
</tr>
<tr>
<td>F</td>
<td>(v)</td>
<td>1 (7)</td>
<td>P1 → P3* → P2 → P1 → …</td>
<td>Yes</td>
</tr>
<tr>
<td>G</td>
<td>(ii)</td>
<td>– (3)</td>
<td>P1 → P5 →</td>
<td>P1 → P2 →</td>
</tr>
<tr>
<td>H</td>
<td>(v)</td>
<td>4 (6)</td>
<td>P1 → P3</td>
<td>P1 → P2 → P3* →</td>
</tr>
<tr>
<td><strong>Control group</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>(II)</td>
<td>10 (14)</td>
<td>P1 → P8 → P6 → P7 → P3 → …</td>
<td>Yes</td>
</tr>
<tr>
<td>J</td>
<td>(ii)</td>
<td>8 (12)</td>
<td>P1 → P6 → P7 → P3 → P4 → …</td>
<td>Yes</td>
</tr>
<tr>
<td>K</td>
<td>(v)</td>
<td>10 (13)</td>
<td>P1 → P8 → P4 → P3 → P7 → …</td>
<td>Yes</td>
</tr>
<tr>
<td>L</td>
<td>(iv)</td>
<td>1 (2)</td>
<td>P1 → P2* → P1</td>
<td>Yes</td>
</tr>
<tr>
<td>M</td>
<td>(iv)</td>
<td>– (15)</td>
<td>P1 → P8 → P6 → P7 → P3 → …</td>
<td>No</td>
</tr>
</tbody>
</table>

| indicates a system restart; → indicates problem transition after an incorrect answer; → indicates problem transition after a correct answer |

The average value in the "Number of problems shifts until solved cause of impasse" column is 1.67 for the experimental group and 7.25 for the control group. The average total number of transitions was 5.25 for the experimental group and 11.2 for the control group. In both cases, the experimental group showed lower values compared with the control group, suggesting that this system appropriately shifted to auxiliary problems corresponding to the causes of learner impasses. However, in the "Exercise completed", one out of five participants in the control group failed, while three out of eight participants in the experimental group failed. Therefore, we considered that "Exercise completed" is possibly influenced by the learner’s ability to voluntarily select auxiliary problems in the control group. However, at present, the number of experiment participants is not sufficient, so it is necessary to further investigate the relationship between "Exercise completed" and "Number of problems shifts until solved cause of impasse" after increasing the number of participants. Detailed learning activities are individually investigated from the problem transition history for each participant.
We first describe participants in the experimental group shown in Table 3. Participant-A got stuck on problem P1 due to frictional forces (ii) and (iv), and so moved to an auxiliary problem corresponding to frictional force (ii). Correctly answering problem P5, Participant-A returned to problem P1 and correctly answered it. This suggests that shifting to problem P5 allowed Participant-A to resolve the frictional force (ii) impasse.

Participant-B got stuck on frictional force (iv) in problem P1, and so shifted to problem P2 involving frictional force (iv). After correctly answering problem P2, Participant-B returned to problem P1 and correctly answered it. This suggests that shifting to problem P2 allowed Participant-B to resolve the frictional force (iv) impasse.

Participant-C got stuck on the frictional forces (ii), (iv), and (v) in problem P1. Following the system priority, C first moved to problem P3, which addresses frictional force (v). After correctly answering problem P3, C then moved to problem P2 in accordance with the problem sequencing, and correctly answered that problem. After returning to problem P1 and working on it, C did not arrive at the correct answer, but there was no frictional force (v) among the system-diagnosed causes at that time. This suggests that Participant-C could not correctly answer problem P1, but did resolve the frictional force (v) impasse.

Participant-D is excluded from the analysis in this paper. Participant-D got stuck due to force (II), where the upper object in problem P1 pushed against the lower object. D then shifted to problem P7. However, when problem P7 was correctly answered and problem P6 was attempted, Participant-D got stuck on force (II), in which the upper object pushes on the lower object. Participant-D again returned to problem P7 in the same manner, then moved to problem P6 and provided an incorrect answer. This was repeated many times, seemingly because the auxiliary problem was ineffective and thus inappropriate for problem sequence evaluation.

We next describe the control group participants, where the system does not adaptively present auxiliary problems, allowing learners to self-select auxiliary problems.

After solving problem P1, Participant-I chose problem P8 and then problem P6. In this way, Participant-I tried all the auxiliary problems in order. When the cause of the impasse was determined in the same manner as in the experimental group, Participant-I got stuck on the force of the upper object pushing on the lower object and the frictional forces (ii) and (iv) in the first problem P1. Participant-I attempted problem P7, addressing the force of the upper object pushing on the lower object, and problem P2 for the frictional force (iv). After that, Participant-I answered problem P1, with no error extracted. The auxiliary problem therefore seems to be effective. However, the transition was repeated three times before moving to problem P7 and nine times before moving to problem P2. Participant-I also attempted problem P7 twice. Despite submitting a correct answer on the first attempt, when reattempting problem P1, Participant-I again made a mistake regarding the force of the upper object pushing on the lower object. This is likely because Participant-I did not attempt the problem in sequence, and so could not successfully combine knowledge from problem P7 with that from problem P1. Similar behavior was observed for other control group participants.

Participant-L performed only two problem transitions, selecting the auxiliary problem corresponding to the cause of the impasse on the first attempt and resolving it. This suggests that Participant-L was able to select the appropriate problem by being aware of sources of misunderstanding.

The above results suggest that problem transitions resolve the cause of the impasse as analyzed by the system. This should decrease learning load because there were fewer transitions until elimination of the cause of the impasse in the experimental group than in the control group. Problem sequencing and auxiliary problem presentation in this system thus effectively eliminated impasses. Note that Participant-D was excluded from the analysis in this paper, but is nonetheless an important case. In particular, Participant-D could not resolve the impasse even with problem transitions because the auxiliary problems did not provide appropriate clues. This case requires further investigation in the future.

In addition, the average and standard deviation were calculated in the experimental group and the control group of the total number of answers. The average was 34.25 in the experimental group and 37 in the control group, and the standard deviation was 10.06 in the experimental group and 18.13 in the control group. Since there is almost no difference in the average, it is considered that there is no large difference in the amount of trial and error between the experimental group and the control group.
And since the standard deviation is larger in the control group, it can be seen that the amount of trial and error in the control group varied greatly among individuals compared to the experimental group. This suggests that this system does not suppress the amount of trial and error. Originally, EBS emphasized the promotion of trial and error. But, in this study, we are conducting an activity different from EBS, which is to support learners by issuing auxiliary problems in order to solve the impasse. We would like to improve and investigate the system so that it will have a positive effect on the original trial and error of EBS.

5. Conclusion

We developed a system that introduces an adaptive auxiliary problem presentation function to conventional EBS as a method of supporting problem-solving in EBS. We also evaluated the effectiveness of auxiliary problem presentation through evaluation experiments, using system logs to determine whether the system supports the resolution of impasses. As a result, we found that the cause of the learner's impasse as analyzed by the system was resolved by the corresponding auxiliary problems presented by the system. This suggests that the problem series constructed in this study are useful in resolving impasses.

In future work, we will investigate problem presentation methods that consider learning histories when selecting auxiliary problems. We will then apply such methods to the present system and perform evaluation experiments. We will also examine cases in which auxiliary problems were ineffective and consider more effective alternatives. In addition, we will not investigate only the number of problems shifted until solved cause of the impasse but also the problem-solving time for the experiments in this paper.

Acknowledgements

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References


The Effect of Different Online Procedural Prompts on Student-Generated Questions Task Performance for English Grammar Instruction

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Abstract: Research on the effectiveness of Student-Generated Questions (SGQ) has been researched and studied over the past years, and there is a great deal of literature on how to enhance the process and performance of SGQ via procedural prompts for learners. However, research on the learning effects of different procedural prompts for students in SGQ is scarce. Using a group of 55 English language learners, this paper will argue that students in SGQ will benefit differently from procedural prompts with their different degrees of structures. Based on the results of paired t-test, students in SGQ were found to perform better on the online SGQ task with the ‘main idea’ procedural prompt than with the ‘what-if-not’ procedural prompt in the fluency index. Yet, no significant differences were observed between the two provided procedural prompts in the flexibility index.

Keywords: English grammar instruction, online learning activity, procedural prompts, student-generated questions, task performance

1. Introduction

1.1 Background of the Study

There has been an increasing interest in what and how students can benefit from Student-Generated Questions (SGQ) (Chin & Brown, 2002; Tho, Lai & Navratil, 2020). With scholars finding that students in the process of SGQ encountered problems and difficulties (Yu, 2009), issues regarding how the process of SGQ can be further enhanced with the assistance of different approaches and their effects on facilitating the process of SGQ await to be examined. Some proposed increasing students’ perceived value in the engaged SGQ task so as to influence the use of learning strategies during the process of SGQ (Yu & Wu, 2008). Other researchers advocated that the use of different kinds of instructional arrangements. For example, White and Gunstone (1992) proposed an idea of providing a stimulus in the process of SGQ such as a picture or a diagram on which questions were to be based, or providing an answer to a question, and students were asked to generate a question based on the given answer.

Oftentimes, researchers investigated the concept and use of procedural prompts on students’ SGQ performance, and the main idea and what-if-not procedural prompts are among the most studied and implemented procedural prompts in both research and practice. For example, with the ‘main idea’ procedural prompt, students are directed to think about what and how to generate the questions with answers based on the main idea of the learning materials. Davey and McBride (1986) trained 260 sixth-grade elementary students to use the main idea procedural prompt to generate questions and evaluated the generated questions, and students were found to have a better understanding on the reading passage. Also, third-grade elementary students provided with the main idea procedural prompt were found to have better understanding on the assigned reading passage, which was also found in the study conducted by Cohen (1983). Alternatively, the what-if-not procedural prompt proposed by Brown and Walter (1983) emphasizes having students use a process of varying the conditions, factors or goals of given problems. Swan (2008) found providing the what-if-not procedural prompt eased the process of math-related question generation on students’ learning of secondary level algebra. Other studies have found students who were supported with the what-if-not procedural prompt during the question-generation
process had better question-generation performance in terms of creativity and flexibility indices (Silver, 1997). Students at the tertiary level also reported that SGQ with what-if-not made it possible for them to apply what they learned in class in future settings (Petrilli, Clark, Demarco, Esposito & Giuliano, 2020). Given the effectiveness and affordance of using main idea and what-if-not procedural prompts for students to generate questions, and the distinct nature and unique affordance of the two procedural prompts, when comparing main idea and what-if-not procedural prompts in the SGQ process, it is vital to further understand the application of using the two procedural prompts.

While research aimed at validating the effect of respective procedural prompts on students’ SGQ performance abound, limited research comparing the effects of different procedural prompts for students in SGQ is around. As such, their comparative effects on the process of SGQ are yet clearly known. In light of the fact that procedural prompts are different in terms of levels of support, their effects on learning are expected to vary. Thus, the purpose of the study is to explore the effect of two procedural prompts, main idea and what-if-not, on SGQ task performance for foreign language learners in SGQ.

1.2 The Importance of Learning English and Innovative English Teaching Approaches to Promoting English Proficiency

The idea of learning English as a second or foreign language (ESL or EFL) has been recognized prevalent around the world. The importance of inspiring people to learn English is widely acknowledged throughout the Asian regions, and English has been used as an official language in many places around the world (e.g., Canada, Hong Kong, Singapore, India, Philippine, Malaysia, and so on) (Feng, 2011). Given the increasingly high demand for English proficiency, the effort to encourage students from the elementary to tertiary level to learn English has been highly appreciated. For instance, several universities in Taiwan set regulations for students, which requires university students to pass a certain level of English proficiency in order to get the university diploma (Wu & Wu, 2010). However, the English proficiency level of students in Taiwan still falls behind its neighboring countries in the Asian regions. According to the report by Educational Testing Services (2019), the average score of Test of English for International Communication (TOEIC) of test takers in Taiwan in 2018 ranked 39th out of the 49 participating countries. In light of this, thinking of ways to improve English teaching and learning in Taiwan has been a key concern for English teaching practitioners and learners.

Over the last decade, there are a growing number of studies focusing on innovative ways to improve students’ English proficiency in Taiwan. For example, students at the high school level were found to have improved learning motivation and achievements with the use of mobile devices on English learning (Tsai, Cheng, Yeh & Lin, 2016). The application of instant messaging on English listening and speaking practice was also investigated on English learners at tertiary level and the results showed learners’ satisfaction and motivation were improved (Wang & Cheng, 2017). With the generally positive learning effects of SGQ, and in light of contemporary educational paradigms highlighting designing learning tasks and including instructional practices that allow students to demonstrate the knowledge, skills, and abilities they master in the classroom (Guzman-Orth, Song & Sparks, 2019; Ketterlin-Geller, 2017) and meet their learning needs (Pitoniak, Young, Martiniello, Buteuz, Ginsburgh, 2009), SGQ has been successfully applied by English teachers to support English learning (Song, Oh, & Glazewski, 2017; Yu, Chang, & Wu, 2015).

1.3 Scaffolding Theory

Based on the notions of constructivism and social-cultural-history theory proposed by Vygotsky, scaffolding theory puts forward the important concept of an individual’s knowledge construction through his/her interaction with the surrounding environment (Vygotsky, 1974). It is believed that learners’ intellectual development could be further enhanced with the assistance from the environment, and students could reach their potential development level beyond the existing development level, namely the Zone of Proximal Development (ZPD) (Wood, Burner, & Mercer, 1976).

Since its inception, there have been numerous applications of scaffolding in education (e.g., Azevedo & Hadwin, 2005; Dagoc & Tan, 2018; Davis & Miyake, 2004; Park, Xu, Collins, Farkas, &
Warschauer, 2019) and review papers (e.g., Bakker, Smit, & Wegerif, 2015). For instance, Azevedo and Hadwin (2005) discussed the effectiveness of computer-based scaffolds for developing learners’ self-regulated learning and metacognition and explored how scaffolded support could be provided through questioning via the use of static prompts or templates in a computer-based learning environment. Dagoc and Tan (2018) examined the effectiveness of metacognitive scaffolding on mathematics performance of grade six learners, and the results showed that learners with help on the use of metacognitive scaffolding performed better on their mathematic performance. Park, Xu, Collins, Farkas, and Warchauer (2018) found that English-speaking elementary students with clear guidance in the form of visual-syntactic text format provided by the learning system gradually improved their English proficiency in terms of word usage, writing genre, and strategy use than those without syntactic scaffolding.

Moreover, procedural facilitation suggests the accessibility of external support to help students reduce their difficulty in performing the learning tasks (Knudson, 1988) and research suggested that the structure of presentation of instruction and learning materials influence students’ learning performance. For instance, in the study conducted by Knudson (1988) to examine the effect of using different structures of instruction, namely the highly structure and less structured lessons, on students’ writing performance, students were found to have better writing performance with the less structured instruction due to the fact that students who were given structured facilitation in the process of English writing instruction demonstrated more undetailed information and incomplete sentences in their composition compared to those in the less structured intervention group. That is, structured intervention would negatively influence integrity of writing (i.e., fluency).

Also, the structural presentation of learning materials was also found to significantly influence students’ idea generation and creativity. Unstructured presentation of learning materials was found to ease the process of generating ideas and thus facilitated the creativity (Moran, Sawyers & Moore, 1988). That is, it could be expected that structured instructions and materials would decrease students’ ability to produce their ideas (i.e., flexibility) compared to those who are given the instructions and materials which are unstructured.

Even though it is evident from existing literature that the structures of presentation of instruction and learning materials have impacts on learning, it is still unclear whether the structures would affect SGQ process. That is, the idea of exploring the different procedural prompts with different structures for SGQ has yet been understood closely. That is, even though it is clear that students can benefit from using procedural prompts for students to generate questions, the effectiveness and affordance of using main idea and what-if-not still need to be clarified in terms of fluency and flexibility in the SGQ process.

1.4 Research Questions

The aim of the study is to identify the influence of two different procedural prompts, main idea and what-if-not, on the quality of questions students generate. To address the issues already outlined and to begin to fill the gaps in the previous research, the present study was conducted to answer the following research question: Is there any difference of using main idea and what-if-not on students’ question-generation performance?

2. Method

A study was designed to explore the comparative effects of two procedural prompts to facilitate the task performance of SGQ. Students were asked to generate three questions based on the main idea and what-if-not procedural prompts, respectively, in two separate sessions. In each session, students were asked to generate three multiple-choice questions with four choices, one correct answer, and explanation.

2.1 Participants, Study Context and Study Materials

The participants in this study were 55 non-English majored freshmen at a university in southern Taiwan. All participants did not have prior experience in SGQ before the experiment. Their English proficiency
level was A2 based on the Common European Framework of Reference for Languages: Learning, Teaching, Assessment (CEFR), and they had the essential computer-related abilities to engage in the online SGQ learning activity.

The instructional materials adopted by the researchers were based on the textbook selected by the participating university for this course, Freshman English. This course is a required course for all freshmen. The selected topic for SGQ was quantity pronouns, and the SGQ task intended to induce students to actually use the grammar, stimulate them to hypothesize, predict, experiment, and reason thoughts, ideas, and explanation (Chin & Brown, 2002) instead of simply memorizing the meaning and usage of the focal concept.

2.2 Procedural Prompts and Study Procedures

A study was conducted to examine the comparative effects of two procedural prompts on SGQ task performance. The experiment took two weeks. On the first week, students were given instruction by one of the authors on the targeted grammar (i.e., quantity pronouns) for 50 minutes and on the second week students were given 50 minutes to generate three questions based on the main idea and what-if-not procedural prompts, respectively, in two practice activities. In each activity, students were asked to generate three multiple-choice questions with four choices, one correct answer, and explanation.

2.3 The Online Learning System

An online learning system developed by one of the authors, QuARKS (Yu, 2009), was used for the participants to generate questions in the study. In the system, participants can generate questions with different fonts, sizes and styles through the use of tools provided by the system. Also, above the tool, there is a link providing access to the procedural prompts for the participants’ reference during question-generation (see Figure 1). Thus, when students generate questions via the main idea procedural prompt, they simply click the link, and the system will direct them to a list of learning objectives/key concepts. Students first did the grammar-related practice and they were guided to review the main idea of the grammar, and then generated questions with the use of main idea procedural prompt (see Figure 2).

On the other hand, the overall procedure of implementing what-if-not procedural prompt is depicted in Figure 3. When participants were asked to generate questions with reference to the what-if-not procedural prompt, they were given access to the practiced questions for question-generation (Figure 4) and then they could change some part of the questions to generate questions. The overall procedure of implementing what-if-not procedural prompt was depicted in Figure 4.

![Figure 1. Screenshot of the Area for the Participants to Generate Questions](Image)
2.4 Measurements

To examine the effect of two different procedural prompts on the students’ SGQ task performance, each of the questions generated by the participants was evaluated against two sets of criteria for the fluency and flexibility index, respectively. The criteria for the fluency index include the correctness of formats, punctuation marks, spelling, grammar, and the answer, the completeness of the question (with four
options, one correct answer, and explanation), the adaption of the procedural prompts in the generated questions, and the appropriateness of the explanation (Yu & Wu, 2013). The criteria for the flexibility index stressed the interconnectedness of the key concepts contained in the questions. Since English grammars instruction is the focus of the practice session, students’ generated questions were analyzed with regard to whether the questions assessed (a) the key concepts or (b) related English grammar of the selected English grammar of the present study, (c) included previously taught English grammar, or (d) used English grammars which haven’t been taught. The detailed criteria are listed in Table 1.

### Table 1. The Grading Criteria for the Fluency and Flexibility Indices for the Questions Generated by the Participants

<table>
<thead>
<tr>
<th>Criteria</th>
<th>SGQ with main idea</th>
<th>SGQ with what if not</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluency</td>
<td>4.22</td>
<td>3.47</td>
<td>87</td>
<td>0.06</td>
</tr>
<tr>
<td>Flexibility</td>
<td>2.43</td>
<td>2.12</td>
<td>81</td>
<td>0.74</td>
</tr>
</tbody>
</table>

Note: The scores used for the paired sample t-tests were the average mean of the three generated

2.5 Data Analysis

To investigate the effects of the two different procedural prompts on student SGQ task performance, an analysis of paired-sample t-tests was adopted. Each of the six generated questions by the participants was evaluated for the fluency index while the three questions generated with the main idea and what-if-not procedural prompts, respectively, were examined as a unit for the flexibility index.

3. Results

As shown in Table 2, the quality of the questions generated by the participants using the two different procedural prompts reached statistical difference in terms of fluency, \( t(55)=2.87, p=.006 \); nonetheless, the flexibility index didn’t reach statistically different level, \( t(55)=1.81, p=0.74 \). That is, students using the main idea procedural prompt produced significantly better question quality than using the what-if-not procedural prompt in the fluency index while using main idea and what-if-not didn’t show any statistical difference in the flexibility index according the results of the present study.

### Table 2. Paired-sample t-tests Results of SGQ Task Performance with the two Procedural Prompts (n = 55)

<table>
<thead>
<tr>
<th>Criteria</th>
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</tbody>
</table>

Note: The scores used for the paired sample t-tests were the average mean of the three generated
questions in terms of fluency and flexibility.

4. Discussion & Conclusion

The present study is preliminary research comparing the effectiveness of using the main idea and what-if-not procedural prompts on students' SGQ task performance. A major finding is that the participants with the use of main idea procedural prompt when constructing questions performed significantly better than using the what-if-not procedural prompt in terms of fluency, but the participants had similar performance under the two procedural prompts in terms of flexibility.

One possible reason for there being a statistical significance on students’ SGQ task performance in terms of fluency may lie in the assigned tasks the main idea procedural prompt involves. For students who were asked to construct questions based on the use of main idea, they first reviewed the main idea of the learning materials and then construct the questions based on the found ideas while what-if-not procedural prompt (Brown & Walter, 1983) consists of structured steps in which students were given explicit instruction on the steps to follow, and According to scaffolding theory, it suggests that the process of SGQ would be more accessible (Swan, 2008) since they are given more guidance in SGQ process but structured intervention was found negatively influence the integrity of students’ writing performance (Knudson, 1988). Similar finding was found in the present study. Students with the use of main idea, which is considered more freely generating process, significantly performed better than using what-if-not, which, on the other hand, is considered more structured (Swan, 2008). One possible reason may be that students who are given structured intervention may rely more on following the instruction given by the instruction and the provided procedures of generating questions, which was also found in the study conducted by Knudson (1988), in which students were found to have more “answers to the questions” instead of the detailed information and completed sentences in the writing composition. Much of students’ attention may be directed to the steps of generating questions through the use of what-if-not procedural prompt the presentation of which was explicit and students were given clear guidance on using what-if-not. Another possible reason may be that the participants of the present study are familiar with the notion of main idea, which might help them better employ the use of main idea procedural prompt when constructing questions.

According to the literature, unstructured representation would give students more freedom and thus result in better learning performance (Kundson, 1988) and flexibility (Moran, Sawyers & Moore, 1988). The results of the present study are not in contradiction with those of the empirical studies discussed above. With regard to the flexibility of the generated questions by the students, our findings confirm those of Moran, Sawyers and Moore (1988), although the difference doesn’t reach the statistically significant level in the present study. These results lend some evidence? to the hypothesis that unstructured representation would contribute to enhancing students’ flexibility.

5. The Contributions and Limitations of the Study and Suggestions for Future Studies

The present findings provided the empirical findings on the effectiveness of using the two different procedural prompts with different structures used in SGQ. One finding is that students with the use of unstructured procedural prompt, the main idea, significantly performed in terms of fluency better than using the structured procedural prompt, the what-if-not procedural prompt; However, the results didn’t show any statistical difference on using the two procedural prompts in terms of flexibility.

Since there were only two kinds of procedural prompts used in the present study, future studies could focus on the effectiveness of the other procedural prompts or arrangements on SGQ performance such as question types, story grammar and generic question stems. Other challenges the researchers of the present study faced was that the experiment was conducted in one instructional session, adopting one group of students. Future study could gather the data from participants exposed to different treatment groups on a longitudinal basis.
Acknowledgement

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References


Preliminary Study on Learning Assessment by Using Problem Posing in an Online Course as an Alternative Method of a Conventional Examination

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Abstract: In 2020, due to the COVID-19 pandemic, universities had to conduct online courses, and instructors were required to use assessment methods other than conventional examinations. This paper reports a preliminary study on learning assessment by using problem-posing in an online course. We investigated whether students who learned well from the course succeeded in solution-based problem-posing without specific training on the skill. The results revealed that students who did well on tests during the course achieved high scores, indicating the possibility that this assessment method can provide an alternative to conventional examinations.

Keywords: Problem-posing, assessment, online course

1. Introduction

In 2020, many aspects of everyday life, including education, were changed by the COVID-19 pandemic. Due to governments imposing lockdowns or issuing stay-at-home requests, universities and other types of schools worldwide had to conduct classes using video-conferencing software or as online courses without sufficient time to prepare. Since online courses using learning management systems (LMSs) and blended learning, which combines classroom methods and online courses, have been widely accepted in recent years, many people could have potentially managed to provide instruction or to learn during the disruption caused by the pandemic. However, for many online courses, instructors were required to change their usual assessment methods from conventional examinations. Students generally take such examinations in a classroom, solving problems with pencils and paper, without referring to any materials (e.g., textbooks or online sources). However, since the pandemic prevents students from gathering in close spaces, such classroom-based, restricted examinations are not viable to use for assessment. Therefore, in the current situation, instructors need alternative assessment methods that account for the assumption that students may refer to any available materials.

This paper reports a preliminary study on learning assessment in an online course, which can serve as an alternative to conventional examinations. Here conventional examinations are supposed a task to solve problems similar in some aspects to but different in the others from those used in instruction or learning. We adopted a problem-posing task, in which students created new problems based on ones they had studied during the course. We investigated whether students who learned well from the course completed the task successfully without receiving additional training.

2. Theoretical Background

2.1 Problem-posing and its Use as an Assessment Tool

The most traditional learning activity is to solve problems provided by a teacher or from textbooks. However, in addition to problem-solving, problem-posing, by which learners create problems by themselves, has also been identified as an important educational activity. Problem-solving and problem-
posing are not entirely different cognitive activities but are closely related. Experimental findings have shown a correlation between problem-solving ability and problem-posing performance (e.g., Ellerton, 1986; Siver & Cai, 1996). Problem-posing has also been used during instruction and learning activities in actual classroom settings, and its effects have been confirmed (e.g., Hirashima, Yokoyama, Okamoto, & Takeuchi, 2007; Yamamoto, Kanbe, Yoshida, Maeda, & Hirashima, 2012).

The use of problem-posing to assess students’ understanding and transfer of knowledge has also been discussed (Mestre, 2002), with some studies empirically investigating problem-posing as an assessment tool (Cai, Moyer, Wang, Hwang, Nie, & Garber, 2012; Mishra, & Iyer, 2015). However, there is a simple but critical issue to using problem-posing in assessment, in that it is a difficult task to perform. Students tend to create simple problems and occasionally fail to compose appropriately solvable problems, even when they can easily solve problems in the same task domain (Kojima, Miwa, & Matsui, 2013a; 2013b). In fact, Cai et al. (2012) found that only a small number of students posed valid problems during an assessment. To facilitate posing problems, Mishra and Iyer (2015) asked students to perform the task in pairs. These findings imply that merely adapting a problem-posing task to be an assessment would not be appropriate, as many students could fail such an assessment without receiving problem-posing training.

Our previous study confirms that many students succeeded in a type of problem posing (Kojima, Miwa, & Matsui, 2013a). This type was solution-based problem-posing (Hirashima, et al., 2007), in which students compose problems that can be solved with a solution specified. The problem-posing practice by Hirashima et al. has adopted this type and successfully facilitated children’s learning of arithmetic word problems in both of problem-solving and -posing skills. Solution-based problem-posing by students can be effectively facilitated by showing examples (Kojima, & Miwa, 2008). Thus, this type of problem posing was expected to be feasible in assessing student learning.

2.2 Student Behaviors and Online Course Performance

Many studies have explored relationships among attendance, engagement, and other student behaviors related to online courses and learning performance (e.g., Goda, Yamada, Kato, Matsuda, Saito, & Miyagawa, 2015; Mogus, Djurdjevic, & Suvak, 2012). Findings from these studies revealed that students who frequently viewed courses and worked on their assignments appropriately tended to show high performance levels, and students who finished each assignment at an appropriate pace performed higher than those who procrastinated. Accordingly, we investigated student performance in a problem-posing task as a course assessment and student behaviors, as recorded in log data in an LMS.

3. Methods

3.1 Course Overview

The investigation was conducted in 2020, during a database course in the department of information and electronic engineering in the author’s university. This 14-week course included 13 lectures and practice performing database operations with SQL. Each lecture was presented via an LMS each week and comprised an instructional video, worksheet, and test. Students could view each lecture anywhere and at any time after they were presented. Each worksheet included questions and students were to answer by referring a textbook. Each test included 7–10 problems, and each problem was randomly select from a set of 3–6 problems. Thus, the tests included different problems for each student who took it. Table 1 shows an example of a set in a test. Students were instructed to take each test repeatedly until they answered at least 80% of the problems correctly (we call this pass) as a requirement for course credit. They were told that the number of tests in which they scored 100% would be added to the final course score. They were encouraged to pass each test in the week it was presented.

After the last lecture was presented, an instructional video for the course examination was also provided. The examination included six problems (bases), each of which was used in one of the tests from the 13 lectures. Students were asked to pose a new problem from each of the six bases, which had
a solution with a structure the same as the base, but a different situation. Here, situations denote surface information about contextual settings such as “customers order items when online shopping.” The first of the six bases is presented as “(a)” in Table 1. The instructional video explained how to pose a problem identical to the base in solution, but different in situation, by using the set presented in Table 1. This explanation was intended to provide examples of solution-based problem-posing. Mere duplication of any problems from the 13 tests administered during the course or the textbook was not acceptable. Students were also encouraged to create situations that differed from any of the bases. The video directly identified situations students were to avoid. They were then presented a rubric for assessing solutions and situations, which is illustrated in Table 2. Students were encouraged to enhance solutions, if possible, and they composed their problems in document files and then submitted using the LMS assignment function. This assignment function enables an instructor to mark a student’s response using a rubric and show the rubric to the student before submission and after marking.

In 2019, the course was conducted using blended learning. This course was identical to the 2020 course, except all lectures and practice took place in a computer room during the class hour, the lecture provided instructions directly in the room, and the examination used conventional methods (i.e., 20 problems created by altering ones from the tests administered throughout the course). Data from the 2019 course were also used in analysis described below.

Table 1. Example of a Test Set (Problem 4 on the Sixth Lecture Test)

<table>
<thead>
<tr>
<th></th>
<th>(a) A table employee has columns of employee_id, name, office_id, and service_years. Describe a relational-algebra expression that can perform operations the same as the following SQL statement.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SELECT name, office_id FROM employee WHERE office_id IN (“E1”, “E2”, “E3”)</td>
</tr>
<tr>
<td>Solution</td>
<td>π\text{name,office_id} (σ\text{office_id = “E1”} ∨ σ\text{office_id = “E2”} ∨ σ\text{office_id = “E3”}) employee)</td>
</tr>
<tr>
<td></td>
<td>(b) A table student has columns of student_number, name, department_id, and gpa. Describe a relational-algebra expression that can perform operations the same as the following SQL statement.</td>
</tr>
<tr>
<td></td>
<td>SELECT name, department_id FROM student WHERE student_number IN (“19E221”, “19E222”, “19E223”)</td>
</tr>
<tr>
<td>Solution</td>
<td>π\text{name,student_number} (σ\text{student_number = “19E221”} ∨ σ\text{student_number = “19E222”} ∨ σ\text{student_number = “19E223”}) student)</td>
</tr>
<tr>
<td></td>
<td>(c) A table order has columns of order_id, user_id, item_id, and number. Describe a relational-algebra expression that can perform operations the same as the following SQL statement.</td>
</tr>
<tr>
<td></td>
<td>SELECT user_id, item_id FROM order WHERE item_id IN (“S500CK1”, “S500CK2”, “S500CK3”)</td>
</tr>
<tr>
<td>Solution</td>
<td>π\text{user_id,item_id} (σ\text{item_id = “S500CK1”} ∨ σ\text{item_id = “S500CK2”} ∨ σ\text{item_id = “S500CK3”}) order)</td>
</tr>
</tbody>
</table>

Table 2. Rubric for Assessing Student Problems

<table>
<thead>
<tr>
<th></th>
<th>0 points</th>
<th>1 point</th>
<th>2 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solution</td>
<td>Simpler than base, inappropriate solution, or duplication of tests or textbook</td>
<td>Identical to base, or different but of equivalent complexity</td>
<td>Successfully enhanced base</td>
</tr>
<tr>
<td>Situation</td>
<td>Identical (employees’ offices, student enrollment, order in online shopping, library books, or bank accounts)</td>
<td>Different</td>
<td></td>
</tr>
</tbody>
</table>

3.2 Data Analysis

Each problem’s solution and situation were scored using the rubric shown in Table 2. Here, we separately calculated scores for the solutions and situations of the six problems each student created. Total scores for the solutions and situations were used to measure examination performance in the 2020 course. Some examples of student problems were shown in the Appendix. In the 2019 course, performance was measured based on the total number of problems each student correctly solved.

Student behaviors in the course were analyzed with log data for the 13 tests. Each single test response was indexed with two dimensions: time and pass. For the time dimension, a response for a test was labeled with the first week (F) if it was submitted within a week after the test presented, the last week (L) if submitted within a week right before the deadline (2020)/the day the examination was conducted (2019), or the middle weeks (M) if submitted between the first and last weeks. For the pass
dimension, each response was labeled with passed (P) if the maximum test score before the response was already 80% or higher, or not passed yet (N) if the maximum score was lower or it was the first response for the test.

Students who submitted many responses, especially F and P responses, could be regarded as those who learned well. Accordingly, it was predicted that numbers of F and P responses would be positively correlated with examination scores. Similarly, students who submitted many L and N responses could be regarded as procrastinators. Accordingly, it was predicted that L–N responses would be negatively correlated with examination scores.

4. Results

In total, 44 students enrolled in the database course, and 27 of them submitted the examination in 2020. In 2019, 56 out of 58 students took the examination. Table 3 shows the examination scores, and Figure 1 presents the average numbers of responses submitted to a test from a student. For each lecture, students in the 2020 course submitted about six test responses, compared to about seven in 2019.

We analyzed correlations between examination scores and number of responses by calculating Spearman’s rank correlation coefficients, which are shown in Tables 4, 5, and 6. As presented in these tables, situation scores were not correlated to test responses, whereas solution scores were significantly correlated to F responses, marginally correlated to P, F–N, and F–P. Furthermore, solution scores were negatively correlated to L and L–N responses. Examination scores in 2019 were significantly correlated to P, M–P, and L–P, and marginally correlated to F–P. They were also marginally, negatively correlated to L–N. These results confirm that F and P responses were negatively correlated to examination scores and L–N.

Table 3. Examination Scores

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>SD</th>
<th>max</th>
<th>min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solutions 2020</td>
<td>3.44</td>
<td>1.77</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Situations 2020</td>
<td>3.93</td>
<td>1.76</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Number correctly solved 2019</td>
<td>11.14</td>
<td>3.64</td>
<td>19</td>
<td>3</td>
</tr>
</tbody>
</table>

![Figure 1. Average number of responses for a test from a student.](image_url)

Table 4. Correlations between Examination Scores and Number of Responses (Solutions 2020)

<table>
<thead>
<tr>
<th></th>
<th>time</th>
<th>pass</th>
<th>numbers of responses</th>
<th>correlations</th>
<th>test statistics</th>
<th>p-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>All</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.098</td>
<td>.49</td>
<td>.630</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>4.84</td>
<td></td>
<td>-2.03</td>
<td>1.20</td>
<td>.241</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>0.97</td>
<td></td>
<td>.340</td>
<td>1.81</td>
<td>.082</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>1.71</td>
<td></td>
<td>.397</td>
<td>2.16</td>
<td>.040</td>
</tr>
<tr>
<td></td>
<td>F–N</td>
<td>1.27</td>
<td></td>
<td>.367</td>
<td>1.97</td>
<td>.060</td>
</tr>
<tr>
<td></td>
<td>F–P</td>
<td>0.44</td>
<td></td>
<td>.341</td>
<td>1.81</td>
<td>.082</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>1.96</td>
<td></td>
<td>.029</td>
<td>0.15</td>
<td>.885</td>
</tr>
<tr>
<td></td>
<td>M–N</td>
<td>1.53</td>
<td></td>
<td>.028</td>
<td>0.14</td>
<td>.890</td>
</tr>
</tbody>
</table>

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5. Discussion and Conclusions

The results described above revealed that students who took the LMS tests during the week they were presented and submitted many responses after passing had high examination scores in terms of the solutions they composed. Similar trends were observed in the conventional problem-solving examination; however, no such trends were observed in terms of situations. That may have been because no students found it difficult to set situations, whereas composing solutions depended on how well they had learned the course material. These findings suggest the possibility that assessments using solution-based problem-posing can serve as an alternative to conventional examinations.

As Table 3 shows, the average solution score for student problems was 3.44 and the max was 8, although a perfect score was 12. In all, the students posed 140 problems, but only 6 problems of them successfully enhanced the solutions. Our previous studies (Kojima & Miwa, 2008; Kojima, Miwa, & Matsui, 2013a) demonstrated that novice students pose few problems with enhanced solutions without first receiving supportive interventions or training. In fact, a few problems received 0 point for their
solutions, because they failed to compose appropriate solutions as a result of challenging in enhancement. This can be a design issue related to using problem-posing as an assessment method.

Although this was not the central issue in the current study, student behaviors were different between the 2019 (blended) and 2020 (entirely online) courses. As illustrated in Figure 1, numbers of F and P responses were lower in 2020 than in 2019, while there were more L–N responses. The higher number of P responses in 2019 may indicate that students had to practice problem-solving for the examination. Few F and many L–N responses may indicate that there were more procrastinators in 2020. It is well known that many students drop out of online and distance learning courses, and it has been well argued that self-regulation strategies are more crucial in the situation (e.g., Goda et al., 2015).

As described in Section 2, problem-posing is regarded as promising an assessment tool. Mestre (2002) suggested problem-posing be used as a diagnostic tool for pedagogical purposes. In fact, some student problems in this study exposed inappropriate understanding of database-related concepts (e.g., functional dependencies and lossless-join decomposition). Such problems received 0 points for their solutions. However, other student problems with zero-point solutions suffered from minor errors, such as inappropriate directions for inequalities (score \( \leq 60 \) and score \( \geq 80 \)). Although this study preliminary evaluated solutions with simple rules, as described in Table 2, we must design an evaluated method that can effectively detect and distinguish minor and essential errors in future work.

References


Appendix

Examples of problems posed by students from (a) in Table 1
A table *furniture* has columns of *furniture_name, theme, size, category*, and *color*. Describe a relational-algebra expression that can perform operations the same as the following SQL statement.

\[
\text{SELECT furniture_name, category FROM furniture WHERE theme IN ("cute", "simple", "chic")}
\]

**Solution**
\[
\pi_{\text{furniture_name, category}}(\sigma_{\text{theme} = \text{"cute"}} \lor \sigma_{\text{theme} = \text{"simple"}} \lor \sigma_{\text{theme} = \text{"chic"}})\text{furniture})
\]

(1 point for the solution and 1 point for the situation)

A table *human* has columns of *id, name, nationality, and age*. A table *android* has columns of *id, produced_date, nationality, and age*. Describe a relational-algebra expression that can perform operations the same as the following SQL statement.

\[
\text{SELECT id FROM human NATURAL JOIN android WHERE nationality IN (}
\text{SELECT nationality FROM human WHERE nationality IN ["Japan", "USA", "Russia", "China"]}
\text{OR}
\text{SELECT nationality FROM android WHERE nationality IN ["Japan", "USA", "Russia", "China"]}
\text{) AND human.age < 65}
\]

**Solution**
\[
\pi_i((\sigma_{\text{nationality} = \text{"Japan"}} \lor \sigma_{\text{nationality} = \text{"USA"}} \lor \sigma_{\text{nationality} = \text{"Russia"}} \lor \sigma_{\text{nationality} = \text{"China"}})\text{human} \lor (\sigma_{\text{nationality} = \text{"Japan"}} \lor \sigma_{\text{nationality} = \text{"USA"}} \lor \sigma_{\text{nationality} = \text{"Russia"}} \lor \sigma_{\text{nationality} = \text{"China"}})\text{android}) \land (\text{age}<65))\text{human*android)
\]

(0 points for the solution and 1 point for the situation)
From Micro to Meso:  
Scaling of a Teacher Noticing Study

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Abstract: Teacher noticing is specialized to its purpose of noticing events and students that are central to the teachers’ professional goals. This study extended prior work of teacher noticing beyond case studies of individual classrooms into implementation across several schools, leveraging eye-tracking and video technologies to collect and analyze teacher-noticing patterns that complement video-based reflective dialogues for additional insights. Practices at the micro level (single school) were reconsidered and implemented at a higher meso level (across multiple schools) in this study. The findings show that differences between teachers’ noticing patterns across schools may be attributed to school cultures, teaching strategies, and teacher beliefs, backed by eye-tracking data analyses and reflective dialogues.

Keywords: Teacher noticing, eye tracking, learning analytics, micro to meso, scaling

1. Introduction

Learning analytics, the use of analytics in the understanding of teaching and learning, has leveraged new methodologies and technologies to make sense of data and provide insights for the school stakeholders, including educators, learners, and researchers (Knight & Shum, 2017). It has an impact on teachers who co-design the analytics with researchers, monitor the implementation in the classroom, and readily seek out the value and benefits of applied analytics that may affect future lessons.

One specific area of impact is on improving teaching practices. Various mechanisms and concepts in teacher research have helped to improve teaching practices, such as professional learning networks (e.g., Ledford, 2016) and use of interactive online tools (e.g., Kuosa et al., 2016). However, in order to make learning activities more visible and accessible to the teacher, significant inroads into traditional eye movement research, which was previously limited to medical and psychological fields, have been introduced into educational science (Jarodzka, Gruber, & Holmqvist, 2017).

Noticing is a natural phenomenon of human sense-making to interpret one’s goals during lessons; teacher noticing is specialized to its purpose of noticing events and students that are central to professional goals (Sherin, Jacob, & Phillip, 2011). Teacher noticing literature (Jacobs, Lamb, & Philipp, 2010; Schack, Fisher, & Wilhelm, 2017) has generally described noticing to encompass three processes, namely 1) attending to events in an instructional setting, 2) interpreting and making sense of noticed events, and 3) deciding if interventions are necessary based on the analysis. This set of procedures is similar to the theoretically grounded Learning Analytics Cycle (Clow, 2012) that conceptualizes learning analytics work as a cyclic loop to generate, analyze and inform learners. The latter step of informing the teachers, however, is lacking in some of the previous teacher noticing research procedures. This gap was addressed by researchers (e.g., Lee, Tan, & Tan, 2019) using a multilayered approach that aided teachers to adapt their practices in order to cater to dynamic student needs.

Although prior work was found to be effective at a micro level in a single school, the conceptualization and analysis of evidence for improvement in teaching and learning practices can also be conducted on a larger scale, as shown in this study, where the adopted practices were reconsidered and implemented at a higher meso level. This study aims to extend teacher-noticing research beyond case studies of individual classrooms to implementation across several schools, by leveraging on eye-tracking and video devices to gather and consolidate teacher-noticing patterns that are complemented with video-based reflective dialogues for additional insights. The research question guiding this study...
is: “what are the differences between teachers’ noticing patterns across schools and what attributed to these differences, as shown by eye-tracking data analyses and reflective dialogues, in unfamiliar and novel situations?”

2. Methods

2.1 Participants

Three secondary schools across the country participated in this study, of which six teachers, two from each school, were involved. All six teachers underwent formal pedagogic training at a teacher preparation institution before they entered the teaching service. Each pair of teachers comprises an expert and novice teacher, differentiated by experience in teaching practice, and co-teach science lessons to a class in the same school. A novice teacher in the local context has less than three years of teaching experience at the point of this study, while an expert teacher often has more than 10 years of teaching experience and is usually appointed as a mentor for in-service novice teachers and student-teachers undergoing school practicum.

2.2 Data Collection, Processing, and Analysis

Each teacher taught a series of three lessons, during which the teacher was equipped with an eye-tracking device that consists of a forward-facing camera to capture what the teachers saw during the lesson and two inward-facing cameras to track the position of the teacher’s eye pupils. This enabled us to capture two kinds of data, namely, visual data showing what the teachers saw during the lesson and stored in the form of a Point-of-View (POV) video, and eye movement data that allowed us to calculate the teacher’s gaze in real-time and superimpose it onto the POV video. This is shown in Figure 1, where the teacher was reading off the text from a presentation slide during the lesson.

Figure 1. A screenshot from the POV video of a teacher participant, with the gaze point represented by an encircled red cross.

From our previous work (Lee, Tan, & Tan, 2019), we were able to distil insights from a single case study on a micro level. In this study, we scaled up the deployment for two more schools, using similar interrelated and cyclical processes in the multi-layer analysis to firstly scrutinize student activity in the classroom, followed by using a combination of video and discourse data to interpret teacher-student interactions, and finally including eye-tracking data into a concluding analysis for the entire
A summary of potential insights obtained from the respective layers of analysis is shown in Table 1.

<table>
<thead>
<tr>
<th>Layer of analysis</th>
<th>Potential insights from dataset</th>
<th>Example of insight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic layer – Elementary understanding using video analysis</td>
<td>The video analysis in the basic layer can provide an intrinsic understanding of happenings and actions in the classroom without specific attention to detail. This can be used to provide a narrative view of a whole lesson.</td>
<td>The teacher was seen to be communicating with a student as the student walked into the classroom.</td>
</tr>
<tr>
<td>Intermediate layer – A thorough examination of interactions through video and discourse analyses</td>
<td>The discourse analysis helps to provide additional details regarding the interactions between the teacher and students. The transcript may also provide clearer indications that signal the intent of actions that the teacher may or may not subsequently take in the lesson.</td>
<td>The teacher was questioning the student on being late for the lesson, with a tone of frustration and a harsher choice of words, as shown in the transcript.</td>
</tr>
<tr>
<td>Final layer – Triangulated findings using a combination of video, discourse, and eye-tracking analyses</td>
<td>Eye-tracking data can provide clearer statistical and visual indications, such as the number of glances and conspicuous noticing patterns, of why certain actions took place and if any preceding factors (such as subjects or objects) were considered before eventual actions were taken by the teacher.</td>
<td>The teacher’s gaze was in fact alternating between the late student and another group of rowdy students in the classroom, with intention to manage the rowdy students after the reprimand.</td>
</tr>
</tbody>
</table>

After each pair of teachers finished co-teaching a lesson, we conducted a review of the recorded lesson and selected segments of the video that showed teachers’ engagement and interactions with the students for a prolonged period of time. For example, a teacher might be fixated at a portion of the class in silence for a significantly long time and this moment in the lesson could be selected to be used as a concrete talking point during the reflective dialogue with the teachers. This dialogue would also allow researchers to further understand the non-visible processes that were demonstrated in the classroom, such as the interpretation and sense-making of noticed actions and class happenings.

During the reflective dialogue, we relied on Video-Stimulated Recall (VSR; Sturtz & Hessberg, 2012) as a method that replays certain segments of the recorded classroom instruction to provide additional stimulus to the teachers in recalling details from recorded lessons. After the teachers’ reflection, we then shared some of our analyses on noticing patterns with the teachers and identified several practices that could be improved to enhance instructional effectiveness in classrooms. With the observations from the eye-tracking data analyses and insights from the reflective dialogues with teachers, we can then identify factors and reasons that attributed to the differences in teacher noticing during novel situations, and potentially further understand the underlying skills and abilities that teachers may exhibit in unfamiliar circumstances.

3. Findings and Discussion

To answer the first part of the research question on what are the differences between teachers’ noticing patterns across schools, we analyzed data from the entire dataset that comprises 18 lessons, with each
lesson lasting an average of 35 to 40 minutes, which is the typical duration of one period of a lesson in all three schools.

The findings from the lessons were compared across the three schools, which we anonymously name in this study as School D, School K, and School S. In alignment with prior work, we also split the analysis to display expert-novice differences within and between schools as listed in Table 2. This allows us to be able to spot potential trends of noticing exhibited by teachers of various experiences from the same or different schools.

Table 2. Differences in noticing patterns of teachers across schools

<table>
<thead>
<tr>
<th>Schools</th>
<th>Novice Teachers</th>
<th>Expert Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>School D</td>
<td>Gaze repeatedly returns to several fixed regions of the classroom, as if expecting to catch happenings in the classroom</td>
<td>Uses prior knowledge to predict several potential students who would require attention and alternate gaze between them</td>
</tr>
<tr>
<td>School K</td>
<td>Scanning of students from left to right of the classroom and vice versa, but not in order</td>
<td>Constantly scans certain portions of the classroom where students who would likely require attention are seated</td>
</tr>
<tr>
<td>School S</td>
<td>Gaze is random and unorganized, and reacts towards noticed happenings that occur in the classroom</td>
<td>Gaze settles quickly on potential trouble hotspots, then weighs and form connections between pieces of visual information into problem units or conclusions</td>
</tr>
</tbody>
</table>

From Table 1, it was apparent that expert teachers tend to utilize prior experience to guide their noticing around the classroom and quickly focused on problems or potential hotspots. The novice teachers’ noticing was more dispersed and unorganized. These findings coincide with recent studies on expert-novice differences (e.g., Auerbach, Higgins, Brickman, & Andrews, 2018; Wolff, Jarodzka, Bogert, & Boshuizen, 2016) and are likely to be generalizable as we scale the number of observed teachers and schools at the meso level.

The second part of the research question pertains to what attributed to the above-described differences in unfamiliar and novel situations. This can be answered via the reflective dialogues that we conducted with the teachers, which provided us with insights on how teachers perceived and processed visual classroom information, and whether this is affected by factors such as classroom culture, teaching strategies, and teachers’ beliefs, as shown in Table 3.

Table 3. Possible factors attributing to teachers’ noticing patterns

<table>
<thead>
<tr>
<th>Schools</th>
<th>Classroom culture</th>
<th>Teaching Strategy</th>
<th>Teachers’ beliefs</th>
</tr>
</thead>
<tbody>
<tr>
<td>School D</td>
<td>Mostly collaborative culture working as communities of inquiry</td>
<td>Cooperative learning and Q&amp;A style</td>
<td>Adaptive responses to teaching materials and continues working using current resources</td>
</tr>
<tr>
<td>School K</td>
<td>Partially collaborative inquiry and individualistic culture</td>
<td>Direct instruction coupled with scaffolding as a form of teaching strategy</td>
<td>External assistance, such as props and online tools are quite essential for engaging students</td>
</tr>
<tr>
<td>School S</td>
<td>Diverse, anti-authoritarian and potentially disruptive culture</td>
<td>Reactive towards noticed happenings that occurred in the classroom</td>
<td>Proactive and predictive practice required to handle students’ behaviors</td>
</tr>
</tbody>
</table>
Through the reflective dialogues, we found that in School D, as students of mixed abilities were often encouraged to work together in small groups during whole-class activities, the teachers opted to use a cooperative style of learning and often designate a member of the group to answer questions on behalf of the group, as a measure to ensure that all group members actively express ideas and share their answers. In School K, the culture was partially collaborative due to the focus on pair work or groups of three. As the majority of the class was of high ability, teachers identified several students who were unable to catch up to the main cohort and assisted their learning with scaffolds. However, individualistic culture also surfaced in the form of competitive answering and argument between students during questioning. As for School S, the students were situated in a diverse culture, with some students leaning towards being anti-authoritarianism and disruptive, while there were several students who were keen to learn from the teachers. Therefore, the teachers were understandably on edge whenever engaging this particular class of students and were mostly reactive towards happenings within the classroom.

When we combined and compared the findings from Tables 2 and 3, we are able to obtain a better sense and understanding of how certain factors can lead to specific teacher noticing behaviors. The culture of students belonging to the different schools in this study was fortunately unique in their own respect and largely follow what was observed in other schools and literature (e.g., Squire et al., 2003), which allows us to observe the different teaching strategies that teachers adopt in comparison with their beliefs and how these affect the way they notice during lessons.

We are thus able to identify three types of noticing behaviors that are likely to have resulted from various observed cultures, teaching strategies, and teacher beliefs. First, repeated returns of gazes to same objects is a noticing sequence that most expert teachers tend to exhibit, and occasionally even by novice teachers when they feel insecure in unfamiliar situations and revisit to provide more certainty of a classroom situation. Reactive strategies are then often implemented, including ad-hoc actions and decisions to handle the students, but may also lead to increased chances of mishandling and heightening tensions in the classroom. Second, a systematic and methodical manner of scanning the classroom was also observed in schools that encourage collaborative efforts. Teachers’ teaching strategies and thoughts are organized closely with sensorial perceptions, an observation also seen in Wolff et al’s study (2016), leading to a more considerate and deliberate manner of noticing. Third, faster fixations by the expert teachers were observed as they ignored insignificant visual cues and focused on consequential actions and happenings with a focused and purposive mindset. A proactive stance in an encouraging school environment also helps to cultivate and nurture a more predictive mindset to handle most classroom situations.

<table>
<thead>
<tr>
<th>Noticing patterns</th>
<th>Likely due to</th>
<th>Observed in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revisiting of same areas or objects</td>
<td>Reactive teaching strategy with some prior knowledge and history with the noticed object as a stable configuration</td>
<td>Most expert teachers and some novice teachers to a certain extent</td>
</tr>
<tr>
<td>Systematic and methodical method of scanning the classroom</td>
<td>Collaborative culture and working with communities of inquiry</td>
<td>Both expert and novice teachers, more so during classroom management situations</td>
</tr>
<tr>
<td>Targeted (shorter saccades) and longer fixations at objects</td>
<td>Teacher’s beliefs in proactive practices and predictive thinking to imagine and anticipate actions that can handle likely events</td>
<td>Experienced teachers with expert knowledge</td>
</tr>
</tbody>
</table>

4. Conclusion

The use of teacher noticing in prior work was assessed to be effective at a micro level for a single school and through this study, teacher-noticing research was extended beyond case studies of the single
classroom into implementation across several schools. Eye-tracking and video devices were used to collect and analyze teacher-noticing patterns that complement video-based reflective dialogues for additional insights. We found differences between teachers’ noticing patterns across schools and explored underlying school cultures, teaching strategies, and teacher beliefs that may have attributed to these differences, backed by eye-tracking data analyses and reflective dialogues. Moving forward, due to the copious amount of data that were gathered through this study and prior work, we seek to narrow our scope of analysis on a more specific set of data, such as looking at the moments of silence in classrooms as part of event-oriented inquiry (Tan, Lee, & Tan, 2020). We will also continue to utilize gaze data from a prior study (Lee et al., 2019) and this study to inform novice teachers and aid their practice, as well as continue to involve more teachers as part of ongoing research, so that we can obtain a larger sample size for possible generalization in future work.

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References


Efficiency or Engagement: Two Book Recommendation Approaches in English Extensive Reading

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Abstract: Reading is one of the essential skills in mastering English as a foreign language (EFL). Extensive reading (ER), which is oriented to readers’ pleasure, has been proved to improve various skills of language learning, such as reading, writing, vocabulary, learners’ attitudes etc. Besides, many recommender systems for students have been developed, including systems which recommend English lessons the learner should take next. These systems could foster their positive attitudes to learning, but few studies have dealt with a problem, i.e., which is the better approach to improve learners’ English skills, efficiency-oriented or engagement-oriented. In this paper, we focus mainly on EFL learners’ vocabulary and reading speed, and introduce two English book recommendation methods for Japanese junior-high school students, one of which utilizes knowledge map (KM) and is oriented toward efficiency of learning, and the other employs content-based filtering and aims to promote learners’ engagement. We also propose experimental methods of verifying whether each approach has a positive effect and of comparing which can improve learners’ skills better.

Keywords: Extensive Reading, Knowledge Map, Recommendation, Learning Efficiency, Learning Engagement

1. Introduction

Reading, an ability required for acquiring written knowledge, is one of the essential skills in mastering English as a foreign language (EFL). By many previous studies, extensive reading (ER) as a method of learning foreign language and its effectiveness are well understood. Day and Bamford (2002) offered 10 principles for an extensive reading approach: The reading material is easy; a variety of reading material on a wide range of topics must be available; learners choose what they want to read; learners read as much as possible; the purpose of reading is usually related to pleasure, information and general understanding; reading is its own reward; reading speed is usually faster rather than slower; reading is individual and silent; teachers orient and guide their students; and the teacher is a role model of a reader.

ER is also proved to have positive effects on learners’ reading comprehension (Mason & Krashen, 1997), writing skills (Mason & Krashen, 1997; Mermelstein, 2015), vocabulary (Pitts et al., 1989) and attitudes (Mason & Krashen, 1997).

And now, turning to recommender systems, a great number of systems have been developed. For example, Hsu (2008) developed an English lesson recommender system for ESL (English as a second language) students which took into account readers’ interest and aimed to increase their motivation to learn, but it didn’t consider its learning effect and efficiency. Nishioka & Ogata (2018) proposed a research paper recommender system on the e-book system. It recommended research papers related to lecture materials the students looked at, although failed to make personal recommendations.

However, in extensive reading, it is not considered effective to emphasis efficiency too much and ignore individual’s reading experience. As mentioned above, “the purpose of reading is usually related to pleasure” and “reading is its own reward”; thus, extensive reading must be fun and bring joy to readers. Therefore, when developing computer assisted language learning (CALL) system, we should
also make much account of learners’ pleasure of reading. In our knowledge, nevertheless, few studies have dealt with a problem, which is the better approach to improve learners’ English skills, efficiency-oriented or engagement-oriented.

In this paper, the term “efficiency” is defined as less materials or learning times to gain more learning effect, and the term “engagement” as students’ involvement in learning activity caused by their interest. Besides, we introduce two English book recommender systems, both of which will be implemented on an existing e-book reader system, BookRoll (Flanagan et al., 2018), for junior-high school EFL students in Japan. One of these systems is based on knowledge map (KM) (Flanagan et al., 2019) and is oriented toward efficiency of learning, mostly of learning vocabulary. The other is based on learners’ preference of books and aims to promote learners’ engagement. We also propose an experimental method for answering following 3 research questions:

RQ1. Whether and to what extent does the KM-based book recommender system improve learners’ vocabulary and reading skills in EFL?

RQ2. Whether and to what extent does the preference-based book recommender system improve vocabulary and reading skills in EFL?

RQ3. Which can improve learners’ vocabulary and reading skills in EFL better, the KM- or preference-based book recommender system?

2. System Overview

2.1 Existing Platforms

2.1.1 BookRoll

The book recommender systems we propose are added to existing e-book reader system: BookRoll (Flanagan et al., 2018). BookRoll, linked to an e-learning platform, Moodle (https://moodle.org), provides not only e-book page display and back and forth navigation, but text highlighting, notes taking, text search, bookmark, and material recommendation function. Figure 1a shows the interface of the system. The green button on the top left of the screen allows users to show material recommendations (thereafter we call this button “recommendation button”).

![Figure 1. The Interface of E-book Reader BookRoll](image)

When users push the recommendation button, a recommendation and quiz panel is displayed on the right side of the screen (see Figure 1b). In this panel, users can answer quizzes and jump to the recommended website. With specification as of May 2020, all the quizzes and recommendations are provided from providers of materials.

When users raise events on BookRoll, such as moving pages, clicking recommendation button, answering quizzes, etc., these events and the date they occurred are stored as reading logs to Learning
The logs stored to LRS include event logs retrieved from Moodle (Details will be explained on 2.2). From these features, we think the quiz and recommendation functions are suitable to implement book recommender systems because we could get feedbacks about users’ preference of book and display recommended books with the quiz and recommendation functions, respectively.

2.1.2 Knowledge Map

Flanagan et al. (2019) proposed vocabulary study map, which can be automatically generated from learning materials and the semantics of words they include. Figure 2 shows an overview of an example of vocabulary study map.

![Figure 2. An Overview of an Example of Vocabulary Study Map](image)

In the map they introduced, each node represented a word in English materials, and the words which have similar meanings were connected by edges. Figure 3, which is the detailed view of the red highlighted branch in Fig 2, shows an example of the edges of vocabulary study map. This suggests that the words “until” and “present” should be learned after “since”, and “period” after “until”. Besides, the information of words already learned could also be registered in the map. By this feature, learners can get in contact with more words in less learning time or with less learning materials and memorize them with comparative ease. Therefore, this map could be utilized to help learners learn vocabulary efficiently by introducing new words connected with words already learned.

![Figure 3. An Example of the Edges of Vocabulary Study Map](image)
2.2 System Architecture

Figure 4 shows an overview of the architectures of the proposed book recommender systems.

![Diagram of system architecture](image.png)

2.2.1 KM-based System

Figure 4a corresponds to the architecture of the KM-based recommender system, adopting efficiency-oriented approach. First, all the words which appear in books in a book library are extracted, and a vocabulary study map is generated in the way Flanagan et al. (2019) introduced. The generated map is stored in knowledge map store (KMS). In parallel, reading logs of books and event logs are stored in learning record store (LRS) through BookRoll and Moodle, respectively. Event logs from Moodle include logs about results of word quizzes provided at Moodle. Through the processing of these logs, information of words which each learner has already learned or not is extracted, and this information is saved on the vocabulary study map by weighting each node of the map. The weighted map can be tailored to each learner and stored in weighted KMS. By using the weighted map and the contents of books, the system searches books which includes as many words as possible a learner should learn to maximize efficiency of learning English and recommends them to the learner.

2.2.2 Preference-based System

Figure 4b corresponds to the architecture of the preference-based recommender system, adopting engagement-oriented approach. In this research, we adopt content-based recommender systems, in which the descriptive attributes of items combined with the rating behavior of users are used to recommendations (Aggarwal, 2016). First, the system makes a vector from each content of a book library. We will decide to use either of TF-IDF, word2vec (Mikolov et al., 2013), or BERT (Devlin et al., 2018) according to some demonstration experiment. In parallel, the logs of users’ behavior on BookRoll are stored in LRS. These logs contain not only learners’ reading time, but also whether they...
have taken to the book they read. Using these logs, the system calculates cosine similarity of vectors which represent the contents of the books. In that way, the system recommends books whose contents seem to be similar to those of the ones a learner likes.

3. Method Overview

3.1 Participants and Experimental Period

This study will take place at a secondary school in Japan. This school is a combined junior and senior high school and is equipped with an online learning environment with Moodle. As all the students in this school are provided with their own tablet or PC and internet access at their home, we can trace and analyze their learning logs in real-time. We will target the 3rd grade of junior high school students at this school as research subjects.

The students to participate in the study will be divided into 3 groups, and each group has around 40 students. The first group uses the KM-based book recommender system, the second uses the preference-based system, and the third is a control group to which no recommender system is applied. To answer the three research questions mentioned above, we will evaluate the improvement of English skills of the students in each group.

The experiment will last for 2 months. As detail will be mentioned on 3.3, we will conduct some tests for students to evaluate their English skills.

3.2 Materials

476 English picture-books are stored at a book library and the students can select and read them as they like. These picture-books are classified into several categories by their difficulty, and students can select and read freely which book they want to read among these books. To maximize the effect of ER and evaluate how the proposed systems affect the attitudes of the students, reading the books should not be mandatory for the students, even though it is highly recommended. This reading is supposed to be done at home, not as formal learning at school.

Table 1. The Numbers of Books Classified by CEFR Levels

<table>
<thead>
<tr>
<th>CEFR level</th>
<th>Number of books</th>
</tr>
</thead>
<tbody>
<tr>
<td>pre-A1</td>
<td>42</td>
</tr>
<tr>
<td>A1</td>
<td>201</td>
</tr>
<tr>
<td>A1/A2</td>
<td>10</td>
</tr>
<tr>
<td>A2</td>
<td>79</td>
</tr>
<tr>
<td>A2/B1</td>
<td>92</td>
</tr>
<tr>
<td>B1</td>
<td>17</td>
</tr>
<tr>
<td>B1/B2</td>
<td>10</td>
</tr>
<tr>
<td>B2</td>
<td>10</td>
</tr>
<tr>
<td>B2/C1</td>
<td>10</td>
</tr>
<tr>
<td>N/A</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>476</td>
</tr>
</tbody>
</table>

Table 1 shows the numbers of books which has each CEFR (Common European Framework of Reference for Languages) levels. Most of the books have A1 level (201 books), and the second most have A2/B1 (92 books). Some books have a level of A1+, A2+, etc., but these are counted as books which have level of A1, A2, etc., respectively. The 5 N/A level books did not have information about the level.


3.3 Evaluation of English Skills

The students’ English skills will be evaluated mainly from the viewpoint of reading speed and vocabulary level. First, we will conduct a pre-test for evaluating each student’s reading speed and vocabulary level. The reading speed will be calculated by the reading logs obtained from BookRoll, and the vocabulary level will be evaluated by a standardized vocabulary test which can estimate test-takers’ vocabulary. Similar tests will be conducted during the experimental period several times, and finally, we will conduct a post-test after the period. In this way, we can obtain the data about the change of students’ reading speed and vocabulary level before and after the experiment.

4. Conclusions and Future Work

In this paper, we raised a question, which language learning approach is more effective to learners, efficiency-oriented and engagement-oriented, and proposed an experimental method for answering it. We introduced two English book recommender systems, one of which was designed to maximize the efficiency of learning, and the other was designed to promote learners’ interest in learning English. Both systems can be integrated into existing platforms so that we can trace the change of the students’ behavior and skills.

In future, we will put this experiment into practice in an actual environment through the simulation. Besides, we will build student models according to the students’ English level, which shows typical behaviors of students in each level. This model will be utilized to decide proper intervention in the students to stimulate them to study harder and improve their scores.

Acknowledgements

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References


Learning Analytics for Inclusive Higher Education

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Abstract: Learning analytics is gaining attention and increasingly being adopted in higher educational institutions. Research have shown that learning analytics is promising in addressing high priority issues in education such as prediction of student retention, enrolments, and learning gains. However, learning analytics also presents barriers and challenges for students with disabilities which could prevent them from fully benefiting from learning analytics, hence create inequality in education. This position paper discusses the opportunities and challenges in learning analytics for inclusive higher education, focusing on students with disabilities.

Keywords: Learning analytics, students with disabilities, higher education, inclusion

1. Introduction

Digital technology brings increased opportunities for inclusive education with digital educational resources and delivery methods such as MOOCs and E-learning platforms. More students have access to education that they would not be able to access without digital technology. However, digital technology also create barriers for students with disabilities. According to the World Health Organization, disability is an umbrella term, covering impairments, activity limitations, and participation restrictions (WHO, 2011). Impairments may be physical, mental, intellectual, sensory impairments, or a combination of multiple factors. These impairments may hinder full and effective participation in society on an equal basis with others.

In the time of Covid-19, when universities and colleges were closed down with very short notice, faculties were under time pressure to migrate to digital education. Many barriers and challenges for students with disabilities are created following the rush to digitalization. Inaccessible digital learning platforms and tools such as learning management systems, MOOC platforms, digital exam applications, and inaccessible digital learning materials such as e-textbooks, lecture notes, documents and presentations could prevent students with disabilities from gaining equal information as non-disabled students and from fully engaging in learning activities. For example, if videos are published to students without captions or transcripts, students who are deaf or hard of hearing will not be able to get the information provided by the videos. If images or graphs are used to convey information but without text descriptions, blind students will miss the information. Text with low colour contrast will create barriers for students with low contrast sensitivity or colour blindness. Learning platforms that only support interaction with mouse will create barriers for students who can only use keyboard for interaction. Serif font types such as Times New Roman and Georgia will make the text difficult to read for students with dyslexia. The accessibility barriers and challenges may further cause failure and dropout for students with disabilities. According to Verdinelli & Kutner (2016) students with disabilities are enrolling in online graduate programs at increasing numbers, yet they tend to graduate at lower rates than students without disabilities. The lack of consideration of accessibility in digital education can be one of the reasons. Starcic & Bagon (2014) argued that “ICT-supported learning should be investigated and designed on the basis of universal design, providing accessibility and facilitating inclusion for all”.

Although barriers are continually being dismantled in digital contents and delivery platforms, learning analytics, a relatively new field of research and practice, has not paid much attention to inclusion and accessibility. The lack of accessibility of tools and information can potentially prevent students with disabilities from enjoying the full benefits of learning analytics.
The goal of this position paper is to put inclusive education on the agenda in the learning analytics community. Neil Selwyn (2018) in his keynote speech at the 2018 Learning Analytics and Knowledge (LAK) conference pointed out that learning analytics researchers should take an expert friend position on the health warnings that come with learning analytics. We argue that the lack of consideration of accessibility and inclusion is one of the health warnings and learning analytics can potentially contribute to exclusion of students with disabilities from higher education. It is time that our community becomes aware of the possible barriers learning analytics systems create for students with disabilities and take measures to ensure that they are accessible and inclusive.

2. Background

The number of students with disabilities in higher education is increasing. According to Snyder, de Brey, & Dillow (2019), it is estimated that individuals with disabilities constitute 11% of the college population in the US in 2011/2012, compared to 10% in 2007/2008. In the latest European Student Survey (Hauschildt, Vögtle, & Gwosć, 2018), an average of 18% student in higher education reported to have a disability (including chronic diseases).

Collins, Azmat, & Rentschler (2019) defines inclusive education as occurring when all individuals regardless of exceptionality, are entitled to the opportunity to be included in a regular classroom environment while receiving the supports necessary to facilitate accessibility to both environment and information. In the context of higher education, a large body of research have been carried out to identify barriers by looking into the experiences of students with disabilities, understanding their challenges, and making suggestions on activities, methods and approaches to address the challenges (Moriña, 2017). In addition, research focusing on accessibility of learning management systems (Chen, Sanderson, Kessel, & Królak, 2015), on faculty’ attitudes towards students with disabilities and their knowledge and competence in making digital learning accessible (Chen, Sanderson, & Kessel, 2018), as well as on providing training to faculty on inclusive education (Hsiao, Burgstahler, Johnson, Nuss, & Doherty, 2019) have been conducted and published. Despite of the attempts and efforts to address the challenges and implement inclusive education in practices, including establishing inclusive education policies, strategies, and action plans in higher education institutions, providing training to faculty and staff to increase awareness and competence, making curricula, classrooms, labs and campus accessible, and promoting inclusive practice in pedagogy and assessment (Gibson, 2015; SELI, 2019), there is still a considerable gap between the current state of the art research and practice and a fully inclusive higher education.

Learning analytics as a promising emerging field has demonstrated its benefits in higher education, including targeted course offerings, curriculum development, student learning outcomes, behaviour and process, personalized learning, improved instructor performance, post-educational employment opportunities, and enhanced research in the field of education (Avella, Kebritchi, Nunn, & Kanai, 2016). Learning analytics has the potential to contribute to quality assurance and quality improvement, boost retention rate, assess and act upon differential outcomes among the student population, and enable the development and introduction of adaptive learning (Sclater, Peasgood, & Mullan, 2016).

A quick literature search has revealed that little attention in learning analytics research has been paid to inclusion and accessibility for students with disabilities. A few research have been focusing on integrating learning analytics into serious games in order to provide engaging learning experience for people with intellectual disabilities (Cano, Fernández-Manjón, & García-Tejedor, 2018; Nguyen, Gardner, & Sheridan, 2018). The Journal of Learning Analytics has no publications on students with disabilities in higher education. The only record found was Kaczorowski & Raimondi (2014) which focuses on using video data analysis to facilitate flexible learning optimized for diverse elementary-aged students learning mathematics, including students with learning disabilities. In the conference proceedings of Learning Analytics and Knowledge (2011-2020), there is only one paper on students with disabilities in higher Education. Cooper, Ferguson, & Wolff (2016) in their seminal paper at LAK’16 presented a comparative analysis of completion rates between disabled and non-disabled
students based on a dataset collected in a 5-year period in an e-learning system and identified a large discrepancy between the two groups. Disabled students were found less likely to complete a module than non-disabled students. Although the authors stated that through their work they hope to stimulate others involved in the research, development and roll-out of learning analytics to work towards realising their potential to meet the needs of disabled students, this unfortunately has not been followed up in the learning analytics community.

3. Critical perspectives on Learning Analytics in the Context of Inclusion

Critical perspectives can be viewed through the lens of key activities in learning analytics (Figure 1). A learning analytics cycle generally covers four main interrelated stages: data collection and pre-processing, data modelling, presentation of results, and interventions (Gašević, 2018).

In the data collection and pre-processing stage, what types of data are collected has direct consequence for the other activities followed. Cooper et al. (2016) used student self-declared disability data. However, research have shown that the majority of student choose not to disclose their disability (Roberts, Crittenden, & Crittenden, 2011). In many countries collecting information about students’ disability, family income, and minority status is governed by privacy laws and needs to be approved by a national ethics committee in addition to consent from students.

At the data modelling stage statistics modelling, machine learning and predictive algorithms using different data including demographic and interaction data for classification, ranking, rating have potential risks of digital redlining (Gilliard & Culik, 2016) and discrimination, which can exert potentially harmful effects for some students and student groups. The number of students who declare disability is often low and there are fewer data points for them. They may also use longer time on activities than average. These factors may result in poor representation and poor performance of the algorithms when dealing with data of this student group. Their data risks of being excluded as outliers or edge data even at the pre-processing stage in order to emphasize the dominant patterns at the modelling stage. Cooper et al., (2016) stated that their approach was not valid when the number of disabled students was low and suggested that a minimum of 25 disabled students in a module was appropriate for the comparative analysis of completion rate between disabled and non-disabled students.

When presenting the results from learning analytics algorithms, the interface design can create potential barriers for students with disabilities. Poorly designed information visualization and dashboard with, for example, low colour contrast, lack of keyboard navigation support, lack of text explanation for graphics and chart, could prevent students with disabilities from accessing information presented and making sense of the data. One of the causes of the barriers could be that the design process of student interfaces for learning analytics did not involve students with disabilities. Another reason could be that the designers of the learning analytics interface do not have awareness of the potential barriers and knowledge on how to create accessible visualizations and dashboards. A literature review showed that when evaluating student-facing dashboards the major focus has been on acceptance, usefulness and ease of use as perceived by users (Jivet, Scheffel, Specht, & Drachsler, 2018). However, dashboards are often not evaluated from the perspective of students with disabilities. Accessibility principles and guidelines such as Web Content Accessibility Guidelines (W3C, 2018) have not been taken into consideration when designing visualization and dashboards for learning analytics.

Intervention actions can be automatic or carried out by faculties or students themselves. Faculties and students may take actions based on the results from learning analytics algorithms. Because of the challenges in the previous stages, the interventions have not considered the disability of students. This can prevent faculties from providing effective support to students with disabilities and students from benefiting from learning analytics. In addition, in this stage learning analytics systems often do not provide explanations of their decision-making. Therefore, users often do not have opportunity to understand how the feedback or recommendations are made in the algorithms, and they are not able to influence the process or correct the decisions by the systems so that the systems learn from the feedback and improve the performances for analysing data from students with disabilities.
4. Discussion and Conclusion

In this paper, we have discussed learning analytics in the context of inclusive higher education. Learning analytics has potential to contribute to inclusive education and enhancing learning experiences for students with disabilities. In addition to the general benefits of learning analytics identified in studies as shown in several literature reviews (Avella et al., 2016; Sclater et al., 2016), learning analytics can also contribute to identifying and addressing barriers and challenges students with disabilities face, identifying courses, modules or programs with high dropout rate of students with disabilities, and providing personalized learning path for students with disabilities. Cooper et al. (2016) suggested that by carrying out critical learning path analysis of those modules with high dropout rate of students with disabilities and comparing the critical learning paths of students with and without disabilities could potentially pinpoint where significant accessibility challenges lie that are really impacting on learning.

Inclusion is not only an ethical issue, but also a technological issue and a pedagogical issue. For learning analytics, collecting and using student disability data as well as using student interaction data to predict disabilities (David & Balakrishnan, 2014) pose ethical challenges. From a technical point of view, how to design statistics modelling, machine learning and predictive algorithms in order to handle data from students with disabilities that are often considered outliers or edge data? How to implement algorithmic accountability (Ivarsson, 2017) and increase transparency of learning analytics technologies? How to design and evaluate learning analytics to ensure accessibility and usability for diverse students? It is promising to notice that in recent years user-centred, participatory and co-design approaches have been adopted to learning analytics design (Dollinger & Lodge, 2018). Furthermore, learning analytics design, in particular visualization and dashboard design should follow accessibility principles and guidelines. On the pedagogical level, how can learning analytics identify critical aspects of the learning experience for students with disabilities and support faculties to customise their pedagogical design to adapt to students’ needs? In order for learning analytics to contribute to inclusive education, such questions should be discussed and addressed. This calls for an inclusion by design strategy to ensure that inclusion is integrated into all the stages in the life cycle of learning analytics systems.

Inclusion does not only refer to disabilities, but also covers gender, social, economic and cultural background and status. In Lim & Tinio (2018) considering ‘how the collection, analysis, and use of data about learners and their contexts have the potential to broaden access to quality education and improve the efficiency of educational processes and systems in developing countries around the world’, Gašević (2018) viewed the adoption of learning analytics through the lens of three key challenges facing education systems in the Global South: quality, equity, and efficiency. Equity in this context, does not only refer to education access and general participation in the traditional sense, but
also refers to *education completion rates*, *to the transition from one educational level to another*, and *to overall educational achievement across different groups*, *based on factors such as gender, income, geographic location, minority status, and disabilities*.

Learning analytics can help to address the gap between an increasingly diverse student population and a "one-size-fits-all" approach in education. Student diversity calls for personalized and adaptive solutions to which learning analytics has the potential to contribute. Through this paper we hope to put inclusion on the agenda in the learning analytics community, increase awareness of inclusion among educators, students, designers, developers, data scientists, researchers and other stakeholders, and make learning analytics an essential contributor to success of all students.

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Automatic Entity Recognition based on BERT in Computer Supported Collaborative Learning

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Abstract: Knowledge building plays a critical role in promoting knowledge acquisition and facilitating the retention of target knowledge in computer supported collaborative learning (CSCL). The interactive texts in CSCL environment provide a valuable opportunity for instructors to understand and evaluate the knowledge building process and results. Entity recognition for interactive texts is the first vital step in evaluating the level of knowledge building. However, the methods of manual recognition and key-term matching are widely applied, which not only time consuming and lack semantic understanding for interactive texts, but also the accuracy of recognition is hardly guaranteed. We proposed an automatic, accurate combination method to recognize knowledge entity based on a state-of-the-art natural language processing model-BERT (Bidirectional encoder representation from transformers) to understand semantic meaning of interactive texts in CSCL. Text classification and entity recognition are employed in this study. Adopting BERT automatically classify the whole interactive texts into knowledge and non-knowledge types. Levenshtein Distance (LD) and semantic matching based BERT are used to recognize entity from literal and semantic similarity between student interactive texts and entity corpus provided by teachers. Using 16047 interactive texts produced by 51 groups of college students around the strategies of problem-solving in educational psychology are analyzed. The classification accuracy is 90.07%. 7025 knowledge interactive texts were used to automatic entity recognition and F1 value of concept entity and principle entity recognition are 72.02% and 61.18% respectively, while processes entity is 48.75% and examples entity is 44.32%. The automatic combination method shows potential value in assisting teachers in understanding the level of knowledge building and provide feedback timely in CSCL context.

Keywords: Computer supported collaborative learning, entity recognition, text classification, bidirectional encoder representation from transformers, natural language processing

1. Introduction

It has been widely acknowledged that collaborative learning can facilitate knowledge construction, high-rank thinking ability and communication skills (Harassim & Xiao, 2015). Based on network and technological platforms, CSCL supports students to share and construct knowledge through social interaction (Tchounikine, 2019), conducted by interactive texts that are messages students sent to chat groups or discussion board. However, CSCL could not occur spontaneously, which requires teachers supervise student learning process and results to ensure their learning gain. It is really a challenging problem for teachers to track interactive texts in time when they organize large scale online collaborative learning, that is because large number of interactive texts contains many complex topics are produced by students. So that learning results of each group are hard to handle timely and even which knowledge entities are discussed and which are not in each group is hard to know for teachers. Moreover, evaluating students’ learning gain in a specific task activity is usually judged by the similarity of the knowledge entity to the knowledge entity provided by teachers. Since teachers usually have the comprehension of domain knowledge closely approximate the true representation of that domain, the similarity to an established knowledge entity can be considered as an indicator for measuring the level of knowledge building (Clariana et al., 2009). Therefore, how to automatically and accurately recognize the knowledge entity referred by students in interactive texts has become a vital research problem in CSCL.
There are three problems need to be solved for automatically and accurately recognizing the knowledge entity referred by students in CSCL. The first one is how to extract the interactive texts which contains knowledge entity. Since CSCL is a complicated process of knowledge construction and social interaction, students would generate task orders for organizing leaning activities and express their emotions when they face difficulties and even conduct social regulation. Besides off-task interactive texts will also be produced during learning process (Ding, 2009). Therefore, how to eliminate the interference of irrelevant knowledge topics is an important task for accurately recognize knowledge entity.

Another problem is that since students would express colloquial terms of one concept or explaining one specific knowledge entity in CSCL, which need us to mine literal and semantic meaning of interactive texts at the same time so that we can recognize entities more comprehensively. Otherwise we would miss the knowledge entities are contained in interactive texts. It is important for students to explain their own understanding about one knowledge entity that is because knowledge building positively affects knowledge acquisition (Draskovic et al., 2004). However, it is hard for machines to understand a sentence whose semantic meaning is equivalent to a knowledge entity.

The last problem is that entity recognition is mainly performed on unstructured texts in knowledge graphs. There are so many data can be used for training model and getting the better result. As for the interactive texts in CSCL, the scale of interactive texts corpus is small, which will cause a negative outcome. Besides the manual labeling of training set is a time-consuming task. Therefore, how to understand the target knowledge entity from literal and semantic level in CSCL based on a training-free method is also a difficulty.

Based on the description above, this work would adopt the combination method of text classification and entity recognition to recognize the knowledge entity in interactive texts in CSCL. This work can contribute to the development of automatic learning monitoring and assessment in CSCL.

2. Related work

2.1 Entity recognition algorithm

In computer science domain, entity recognition methods can be divided into two different cases based on the existence of a knowledge base. When knowledge base exists, entity connection can be used for entity recognition. Otherwise, named entity recognition (NER) is involved. The process of entity recognition has changed from extracting noun like time and names of people, locations, institutes in a single field to an open field (Chinchor & Marsh, 1998). Early entity recognition mainly based on the combination of heuristic algorithms and artificial rules (Rau, 1991), or basing on statistical machine learning (Liu et al., 2011). Now, due to the small scale of data in domain entity extraction, iteration is used for extending entity corpus.

In education domain, term extraction plays an important role in entity recognition, which is determined by the educational entity characteristics. Because of the long-tail of term in education domain, general extracting method is not accurate and comprehensive. Term extraction focuses on the simple terms formed by a single word and compound terms formed by several words. The process of extraction mainly contains two steps. Firstly, obtain the candidate terms based on the unity of strings. Secondly, select the real terms by the entity terminology of candidate entities. Unity is to measure the stability of string collections, while terminology is to measure the speciality of the string combinations in specific field (Kageura & Umino, 1996). The terminology of terms can be judged based on some features, including TF (Term Frequency) method, TF-IDF (Term Frequency-Inverse Document Frequency) method, Information Gain and mutual information. Li et al. (2018) came up with the DRTE method to extract terms from unstructured texts automatically, which is based on the sentence pattern mining using term definition and term relation, associating with morphological rules and boundary detection to extract terms. First thing is text pre-processing, then term definition and term relation are used for selecting terms. Patterns are used for performing definition extraction from texts, which can generate initial candidate terms. Then, use morphological rules and boundary detection to select terms,
limiting the length of terms within 2 to 6 words. According to the part-of-speech table, reduce the strict restriction on part-of-speech matching to obtain a boundary word table and use part-of-speech matching analysis to get the final terms, which will make the number of elements of sentence less than 4. Finally, update the term collections and word segmentation results.

2.2 Entity recognition method in CSCL

In order to measure the level of knowledge building, some researchers have conducted studies on how to recognize knowledge entity based on interactive texts in CSCL. The methods of manual recognition and key-term matching are widely used. Zheng et al. (2015) based on knowledge entity provided by teachers and used the manual recognition method to segment information flow generated by students in CSCL processes. Then the values of proposed knowledge building indicators were automatically calculated. Besides, many attempts have been overcome some limitations of manual recognition, which mainly use automatic method to recognize entity by key-term matching. Hong and Scardamalia (2014) used key terms matching extract knowledge entity from interactive texts in CSCL, which are used to indicate and assess level of knowledge building. Zheng et al. (2018) used the key-term-based method to recognize entity and the specific process is as follows: split student’s interactive texts in Chinese by open-source splitting software ICTCLAS (Zhang et al., 2013); replace the key terms by terms in synonyms dictionary and extract the key terms based on knowledge entity provided by the teachers.

Previous studies have indicated that the manual method and the key-term matching method are widely used to recognize knowledge entity in CSCL. However, manual method not only strongly depend on artificial coders, but it is also a post event approach and its results can only be seen when students finish their collaborative learning, which cannot provide real time feedback for teachers and students. Key-term-based method cannot mine semantic meaning of interactive texts in CSCL, which cannot detect interactive texts without key-terms although they have same meaning, and that will lead to the recall rate of the entity recognition is low. In conclusion, it can be noticed that an efficient, real-time and accurate method for automatically recognizing the knowledge entity produced by students in CSCL is lacking.

3. Methodology

The combination method of entity recognition is as Figure 1. In order to conduct entity recognition for knowledge interactive texts. Text classification is conduct firstly, which divide whole interactive texts into knowledge texts and non-knowledge texts. Text classification and entity recognition are included in research method. The specific process in each part can be seen in 3.1 and 3.2.
3.1 Text classification

3.1.1 Classification rules

In order to eliminate the inference of non-knowledge interactive texts, we need to conduct the text classification firstly. All the interactive texts in CSCL can be divided into two kinds, including knowledge kind and non-knowledge kind.

From existed researches, knowledge interactive texts generated in the process of knowledge building which has been defined as organizing, restructuring, interconnecting and integrating new information with prior knowledge (Kalyuga, 2009). Therefore, knowledge texts include explanation, examples and application about knowledge entity. While greeting, manage instruction, confused expression and off-task texts are belong to non-knowledge. There are some examples of knowledge texts and non-knowledge texts in Table 1.

Table 7. Knowledge and Non-knowledge Interactive Texts

<table>
<thead>
<tr>
<th>Type</th>
<th>Interactive texts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td>“Problem solving strategies include algorithmic and heuristic.”</td>
</tr>
<tr>
<td></td>
<td>“In the whole problem-solving process, we should seek more possible methods after analyzing the problem.”</td>
</tr>
<tr>
<td></td>
<td>“For example, take a beautiful photo, it is considered a poor-structure problem.”</td>
</tr>
<tr>
<td>Non-knowledge</td>
<td>“Hello every, my name is Yixin.”</td>
</tr>
<tr>
<td></td>
<td>“Let’s turn to the next question.”</td>
</tr>
<tr>
<td></td>
<td>“We haven’t solved the second problem.”</td>
</tr>
<tr>
<td></td>
<td>“I’m so hungry.”</td>
</tr>
</tbody>
</table>

3.1.2 BERT model

BERT model is pre-trained by deep bidirectional representations in unlabeled text and can be fine tuned with one output layer. And it creates state-of-the-art on many natural language processing tasks including text classification (Devlin, 2018). Multi-layer bidirectional transformer encoder can be seen in the model architecture since transformers have better ability to save training time and pay more attention to important section.

BERT model can be divided into Pre-training part and Fine-Tuning part. Masked Model and Next Sentence Prediction are used to train word vector in Pre-training part. The encoder part of the
transformer model is used for training unit, the start characters [cls] and stop characters [sep] are labeled, then the word vector is output. Words in a sentence is randomly covered or replaced in the Masked Model and then the model predicts the masked words by the context. In the replacement part, Loss calculation only calculates the loss of the covered part. In the NSP task, it mainly calculates whether two sentences are matching.

### 3.2 Entity recognition

Knowledge texts can be extracted by text classification and then entity recognition is performed on them. According to previous research (Yang, 2011), entity have four types which are concept, principle, process and example. The corpus of knowledge entities and entity types is provided by teachers in advance and students need to engage them. Therefore, the main task is how to recognize knowledge entity and their type from knowledge interactive texts based on entity corpus provide by teachers.

Since the generative characteristics of CSCL, students are required to produce new opinions contain new knowledge entities to show their knowledge building which maybe not include in entity corpus provided by teachers. It is reasonable that entity corpus may not completely cover all entities generated by students during the learning process. Our approach is that judging a knowledge interactive text whether contain one or more knowledge entities in the corpus firstly. Then if it contains, we replace the interactive texts with the matched knowledge entities. Otherwise, we need to mark the entity type based on the language template and text length appearing in the text, then it was saved as an entity.

Among them, our approach mainly includes text similarity calculation and regular matching two parts. Text similarity calculation is used to match the knowledge entity with the entity corpus provide by teachers in advance. While the regular matching is used to recognize the knowledge entity which is not exit in entity corpus. Besides, text similarity calculation includes distance method and semantic similarity calculation, which the first one is used to match entity on literal meaning and the second one is used to match them based on semantic meaning.

#### 3.2.1 Text similarity calculation

Levenshtein Distance. Levenshtein Distance (LD) was proposed by Soviet mathematician Vladimir Levenshtein and it is also known as Edit Distance, which is mainly used to compare the similarity of two string. Levenshtein distance refers to the mini-mum number of operations required to convert a string of sequences through insertion, deletion, replacement into another string. The smaller the edit distance, the greater the similarity between the two strings (Li & Liu, 2007). It is widely used in comparing the literal similarity of two short texts.

Semantic matching. Only literal text similarity calculation cannot completely match the entity described by the students with the knowledge corpus, so the method of semantic similarity calculation between two texts needs to be introduced. In this work, BERT sentence vector is chosen as the text representation, which can map a variable length sentence to a fixed length vector. The first text is come from the entity corpus provided by teachers, while the second text is a knowledge interactive text in learning process. Then two text vectors are calculated respectively. Sentence vector similarity is measured using the cosine value. If the cosine value between two sentence vectors is greater than 0.85, it indicates that two sentence vectors are similar (Zhang et al., 2011), which means that the knowledge interactive texts contains the corresponding knowledge entity, otherwise no knowledge entities are contained in it.

Steps of using BERT sentence vector refer to the service provided by BERT-Service¹, and Python is used for performing sentence vector encoding.

---

3.2.2 Regular match

Since knowledge semantic interactive texts are not similar to the knowledge entity in the entity corpus provided by the teacher through the text similarity calculation, that means that they are new knowledge entities generated by students during learning process. The processing method is to obtain the entity type of the entity through regular matching and text length calculation. Among them, the two types of entity are identified by concept and example when performing regular matching. The template used is “is/are” represents the elaboration and explanation of concepts, and “such as”, “for example” represents an example of the facts is presented. After extracting the corresponding entity, we calculated the entity length and presented entities with its length to three domain experts. Experts decided that if the text length is greater than 15 and less than 30, it is classified as a process. If the text length is less than 15, it is classified as a principle. If the text length is greater than 30, they are classified as examples.

4. Experiment and Results

4.1 Data

This research selected data from CSCL platform developed by our laboratory. There are 51 groups participating in learning activity and each group has 4 people. The learning task is to discuss problem-solving strategy in educational psychology, which is same for each group. The task includes 5 parts which include the strategy for problem-solving, the difference between experts and novice in problem-solving, how to develop students’ capability in problem-solving, how to conduct knowledge construction based on problem-solving and the process of ill-structured problem-solving. Before the activity, group members are free to choose one of four roles (coordinator, interpreter, summarizer and information collector). The average time of this CSCL activity is 2 hours for each group.

There are 16047 interactive texts produced by 51 CSCL groups, and 315 texts for each group in average. In order to ensure our dataset to obey the real situation and improve the generalization ability of model, all the original data are preserved. Among all the 16047 texts the data are divided into training set, validation set and test set, 70% of the data in each category is selected as training set, 20% as validation set and 10% as test set. Then two parts of data are combined as the whole training set and test set. The experimental statistics of knowledge and non-knowledge are shown in Table 2.

Table 8. Corpus Distribution of Experimental Dataset

<table>
<thead>
<tr>
<th>Type</th>
<th>Training set</th>
<th>Validation set</th>
<th>Test set</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td>4918</td>
<td>1405</td>
<td>702</td>
<td>7025</td>
</tr>
<tr>
<td>Non-knowledge</td>
<td>6317</td>
<td>1805</td>
<td>900</td>
<td>9022</td>
</tr>
<tr>
<td>Amount</td>
<td>11235</td>
<td>3210</td>
<td>1602</td>
<td>16047</td>
</tr>
</tbody>
</table>

Besides, 57 knowledge entities in entity corpus in Chinese are provided by teachers and it includes 13 concept entities (CN), 11 principle entities (PF), 31 process entities (PS) and 2 example entities (FC). And part of 57 knowledge entities are shown in Table 3.

Table 9. Part of 57 Knowledge Entities Corpus

<table>
<thead>
<tr>
<th>Concept</th>
<th>Principle</th>
<th>Process</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ill-structured</td>
<td>Unclear start</td>
<td>Knowledge construction based on problem-solving</td>
<td>Build a good knowledge architecture system</td>
</tr>
<tr>
<td>problem</td>
<td></td>
<td></td>
<td>Bridge-crossing problem</td>
</tr>
<tr>
<td>Problem</td>
<td>Unclear end</td>
<td>Training of the ability of problem-solving</td>
<td>Differences in understanding and ATM machine</td>
</tr>
<tr>
<td>Will-structured problem</td>
<td>Unclear method</td>
<td>Difference between expert and amateur</td>
<td>Differences in speed of problem-solving</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------</td>
<td>--------------------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>Heuristic method</td>
<td>Strategy of problem-solving</td>
<td>Differences in focus in problem-solving</td>
<td></td>
</tr>
<tr>
<td>Algorithmic method</td>
<td>Process of ill-structured problem-solving</td>
<td>Differences in monitoring the problem-solving process</td>
<td></td>
</tr>
<tr>
<td>Mean-goal analysis</td>
<td>Consolidation of original knowledge and skills</td>
<td>Consider each situation and list each possibility</td>
<td></td>
</tr>
</tbody>
</table>

4.2 Experiments

The computer environment of research is 64 bits Ubuntu operation system, Intel(R) Xeon(R) CPU E5-2620 v4.

4.2.1 Text classification

Firstly, two annotators labeled one third data as 0 and 1 based on whether it belongs to knowledge text or not, while knowledge texts were labeled as 1 and non-knowledge texts as 0. Then we computed the consistency of them, Kappa-value is 0.90. At last, two thirds of the rest data were labeled by two annotators respectively.

Secondly, we modified BERT pre-trained model architecture based our experiment data and chose the pre-training model of Bert_chinese_L-12_H-768_A-12. In the fine-tune part, we set max sequence length is 256, train batch size is 16 and learning rate is 1e-5 according to the previous studies. Thirdly, we predicted the test set by using trained BERT model. Finally, we got the classification result.

4.2.2 Entity recognition

Firstly, we calculated LD between the knowledge interactive texts and knowledge entity in entity corpus provide by teachers based on a Python package called FuzzyWuzzy, which is a fuzzy string matching package. If the value of LD greater than 85, that means knowledge text produced by students contains the correspond knowledge entity in entity corpus (Zhang & Cui, 2020). Secondly, we mined the sematic similarity between knowledge interactive texts by students and knowledge entity from teachers, which include two parts: got the vert sentence vector by BERT-service and calculated the cosine value between two vectors. Finally, we recognized the entity not exit in entity corpus but produced by students with rules and text length.

4.2.3 Evaluation

Evaluation of text classification and entity recognition typically employs the following three metrics: Precision, Recall and F1-measure (F1). The standard indicators of Song et al. (2014) are employed to measure the evaluation.

4.3 Results

4.3.1 Text classification

The text classification result can be seen in Table 10. The F1 value of knowledge text is 88.40% and non-knowledge texts is 91.33%. The total accuracy is 90.07% which is higher to make application in
real education situation. From the confusion matrix of BERT classification model (see Figure 2), we can see the value of diagonal is higher than others which means the classification result is great.

Table 10. *BERT Algorithm Classification Result*

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Types</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Knowledge</td>
<td>Non-knowledge</td>
</tr>
<tr>
<td>Precision</td>
<td>90.58</td>
<td>89.71</td>
</tr>
<tr>
<td>Recall</td>
<td>86.32</td>
<td>93.00</td>
</tr>
<tr>
<td>F1</td>
<td>88.40</td>
<td>91.33</td>
</tr>
</tbody>
</table>

![Normalized confusion matrix](image)

*Figure 2. Confusion Matrix*

4.3.2 *Entity recognition*

7025 knowledge interactive texts were used to further recognize entity and the result can be seen in Table 11. The F1 value of CN (concept) and PF (principle) are 72.02% and 61.18% respectively which is obviously higher than F1 value of PS (Process) and FC (Example) with 48.75% and 44.32%.

Table 11. *Entity Recognition Result.*

<table>
<thead>
<tr>
<th></th>
<th>Recall</th>
<th>Precision</th>
<th>F1</th>
</tr>
</thead>
<tbody>
<tr>
<td>CN</td>
<td>81.77</td>
<td>64.35</td>
<td>72.02</td>
</tr>
<tr>
<td>PF</td>
<td>59.01</td>
<td>63.53</td>
<td>61.18</td>
</tr>
<tr>
<td>PS</td>
<td>60.56</td>
<td>40.79</td>
<td>48.75</td>
</tr>
<tr>
<td>FC</td>
<td>35.34</td>
<td>59.43</td>
<td>44.32</td>
</tr>
</tbody>
</table>

5. Discussion and Conclusions

Entity recognition is the most vital step for automatically assess students’ knowledge building level, which can assist teacher monitor the discussion process and provide learning support timely. This study proposes an automatic, accurate combination method to recognize knowledge entity based on BERT from interactive texts in CSCL context. Text classification and entity recognition are employed in this study were found to be effective in recognizing entity. Text classification is conducted based on BERT, which create a state-of-art in lots of natural language processing tasks including text classification. Literal and semantic similarity between interactive texts and entity corpus provided by teachers are calculated to get matched entity. LD was used to calculate the literal similarity while BERT-service was
used to produce sentence vector and the cosine value between two sentence vectors can indicate the degree of semantic similarity. Besides we can also detect the knowledge entity generated by students themselves rather than required by teachers.

Based on 16047 interactive texts from an educational psychological content problem solving strategy from 51 groups. We adopt the combine method of text classification and entity recognition for recognize the entity in interactive texts. The result is shown that method is valid and we can automatically and accurately. Knowledge interactive texts can be classified accurately, and CN and PF entities can be detected precisely while PS and FC entities cannot be recognized properly. The reason of that is students take lots of examples in knowledge building and it is hard to recognize based on entity corpus while process entity is to explain the knowledge in a subjective procedure way and its similarity with entity corpus is lower than concept entity and principle entity. This method will be especially beneficial for teachers to handle the learning process or learning result of students when they are facing a large number of groups in CSCL context.

One limitation of this study is that the accuracy of process entities and example entities recognition is lower. Students will say more explanation or take more examples which are not in entity corpus or have far semantic distance with them. In all, our model’s ability of detecting new generated entity produced by students is a little weaker and how to improve its’ performance in processes and examples is our future works. For future studies, more attempts should be taken in the optimization of entity recognition model and the improvement of recognition accuracy. So that we can give more powerful supports for teachers to handle learning process of students accurately and timely.

Acknowledgements

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References


The Relationship between Learning Behavior and Learners’ Listening Strategies in Dictation Practice Courseware

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Abstract: This paper explores the possibility of relating psychological factors of learning strategies with log data collected in an online dictation training courseware in Japanese EFL settings. Based on Nix’s (2016) learning strategies question items, we conducted an explanatory factor analysis, producing four factors, each consisting of four question items. Spearman’s correlation analysis showed a few weak correlations between learning behavior and learning strategies. In conclusion, it is suggested that more parameters of personalized data be included in future Personalization/Adaptation studies based on learning analytics.

Keywords: dictation, listening strategies, adaptive/personalized learning, learning log

1. Introduction

This paper, as a preliminary study, discusses whether log data collected during the listening practice can be related with any of the potential psychological constructs, i.e., listening learning strategies of the learners, and whether the constructs can predict some indexes that explain learner’s learning outcomes. Ono (2018) discusses the importance of challenging to explore the possibility that the learning behavior, collected as learning behavior data in an online learning environment, since this might directly lead to the automatized “personalization” and “adaptation” of learners’ learning.

However, in the case of foreign language learning environment, it is not at all clear that online learning behavior is related to individual learner factors of learning strategies, especially in the listening practice environment. Ono (2014) pointed out that behaviors such as intentional “skipping” or “repetition” due to irrelevant purposes makes data more complicated and prediction more difficult in terms of the use of authentic multimedia materials such as TED Talks.

In discussing the learning analytic approach to listening tasks, various types of psychological constructs such as learning strategies, learning styles, and learning motivation could affect learning behavior and learning outcomes. In this preliminary study, the main focus will be on the practice of “dictation,” whereby the learner listens and writes what they hear. This task is cognitively complicated and involves activation of the processing of grammatical, contextual, and phonological knowledge, implying a discussion of the relationship between learning strategies. The result, which will be laid out in this paper, is that there is a limited degree of relationship observed as a result of Spearman’s correlation analysis between listening learning strategies and the certain length of materials to listen to. Lastly, this paper will be concluded with the future research perspectives to explore the potentials of learning analytics to the course design in the classroom.

2. Previous Studies

2.1 Toward More Sophisticated Personalization of Learning Courseware
There is a general agreement that the recent emergence of Learning Analytics (LA) as a distinct field from the applied disciplines of Machine Learning, Data Mining, and Intelligent Tutoring Systems, which in turn evolved in large part from the fields of Applied Statistics, Computational Linguistics, and Cognitive Science (Rosé et al., 2016). LA’s prominence and influence are strongly activated the interdisciplinary field of the Learning Sciences as a whole, and in particular, the CSCL community (Tan & Koh, 2017). To expand the potential as a research-practice bridge in LA, LA-based Personalization/Adaptation has been intensively researched since then. According to the meta-analytic study by Xie, Chu, Hwang, and Wang (2019), the main parameters of personalized data are learners’ preferences, learning achievements, profiles, in addition to learning log data.

It is a fact that language learning is the field in which technology enhanced learning research has been penetrated. However, it is more important to improve accuracy of clustering/prediction models by incorporating further learner factors. Specifically, among the potential factors listed above, Chen et al. (2016) stress the importance of including learning style data in addition to learning behavior data.

2.2 Significance of Dictation Task in Foreign Language Instruction

Compared with reading tasks, listening is considered as a difficult task. According to Field (1999), listening involves two simultaneous processes in the brain: The top-down process and the bottom-up process. The bottom-up process involves understanding words in connected speech, while the top-down process originates from comprehension models such as schema theory, leading to compensation for commonly problematic bottom-up abilities of EFL learners.

Dictation is the process of writing down what someone else has said. Oller (1971) evaluates dictation task as providing the learners with expectancy grammar skills and promoting general proficiency. Heaton (1975) points out that the dictation task predicts such concepts as phonetical discrimination, vocabulary knowledge, grammatical knowledge, listening comprehension and phonological memory span. The task is intended as the activation of both top-down and bottom-up processes. In the field of Japanese EFL research, it is commonly agreed that both processes are interacted in listening tasks: the top-down process is activated especially when the learners cannot understand phonetic information (Satori, 2010).

2.3 Log Data in Listening Practice

The dictation training courseware employed in this study is “CaLabo MX,” produced by CHIeru©, Japan (https://www.chieru.co.jp/products/high-school/calabo-mx/). The screenshots of the interface are shown in Figure 1. In a typical dictation practice courseware, the supporting modules are included in the interface, so that learners can freely choose how to produce the sound from the system. The modules are listed in Table 1 and described in Figure 2 below. These modules are the parameters for the log-data analysis in this study.
Figure 1. Screenshot of dictation training courseware.

Figure 2. Screenshot of the support modules in the courseware.

Table 1. Parameters to Employ in this Study

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Seek the place to start to play (Seek)</td>
</tr>
<tr>
<td>2</td>
<td>Push the Start/Stop button (Start/Stop)</td>
</tr>
<tr>
<td>3</td>
<td>Go back 2 seconds (Back)</td>
</tr>
<tr>
<td>4</td>
<td>Go forward 2 seconds (Forward)</td>
</tr>
<tr>
<td>5</td>
<td>Set the A-B point for repetition (Between)</td>
</tr>
<tr>
<td>6</td>
<td>Change the speed (ChangeSPD)</td>
</tr>
<tr>
<td>7</td>
<td>Go to the end and stop (Complete)</td>
</tr>
</tbody>
</table>

2.4 The Comprehensive Model of Listening Learning Strategies
Since Rebecca Oxford’s Strategic Inventory for Language Learning (SILL: 1990) attracted broad attention within the field of second language acquisition, studies of listening strategies have been discussing the constructs or methods of managing personal mental and observable behavior to accomplish a listening task (Goh & Taib, 2006; Graham & Macaro, 2008; Richards, 2008). Nix (2016) constructed a questionnaire called the EFL Listening Strategy Inventory (ELLSI) to estimate the strength of the latent trait and listening strategy use among the population of Taiwanese EFL learners. The model was based on four relevant theoretical facets. These are (i) learning settings, that is, situations in which EFL listening may occur (Interaction/Conversation, Self-study, Academic); (ii) channels (Face-to-Face, VOIP/Telephony, Webcam, Audio-Visual Media); (iii) strategies (metacognitive, cognitive, and socio-affective); and (iv) processing (Interactive, Top-down, Bottom-up), followed by 23 constructed and validated question items (given in the Appendix below). This paper tentatively assumes that the 23 question items should reflect Japanese EFL learners’ listening strategies as a comprehensive model. In Study 1, an exploratory factor analysis is conducted, and sophistication into the current study will be attempted.

3. Study (i) Factor Analysis

3.1 Research Questions

With these considerations as background, this paper attempts to explore the possibilities of relating learning log data with any of the learners’ listening strategies.

RQ1: How will Nix’s 23 question items be summarized, in the case of Japanese university EFL learners?  
RQ2: What is the relationship between learning behavior and listening strategies in online dictation practice courseware?

3.2 Procedure

A total of 76 first-year students participated in the study in the spring term of the 2020 academic year. The dictation practice courseware was new to all of the students; we therefore designed the first two weeks as training weeks, so that the participants could become accustomed to the system. We collected data from week 5 to week 8 with four different tasks of different sentence lengths. The total log data contained 22,596 lines for analysis. Table 2 shows the summary.

Table 2. Materials in this Study and Number of Log Lines to be Collected

<table>
<thead>
<tr>
<th>Task</th>
<th>Material</th>
<th>Length/Difficulty</th>
<th>Number of logs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The shields are designed to protect passengers from the risk of droplet transmission and are made from transparent polycarbonate.</td>
<td>Medium/Difficult</td>
<td>3,872</td>
</tr>
<tr>
<td>2</td>
<td>Simplicity is the best. We tried to make them the simplest, effective way of keeping people safe.</td>
<td>Medium/Easy</td>
<td>2,411</td>
</tr>
<tr>
<td>3</td>
<td>Estonia is proud of its firsts.</td>
<td>Short/Easy</td>
<td>5,787</td>
</tr>
<tr>
<td>4</td>
<td>It lays claim to being the first country to declare internet access as a human right, the first country to hold a nationwide election online, the first country in Europe to both legalize ride sharing and delivery bots, and the first country to offer e-Residency.</td>
<td>Too Long/Difficult</td>
<td>10,526</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>22,596</td>
</tr>
</tbody>
</table>

3.3 Results

For RQ1, an exploratory factor analysis was conducted to determine the inter-factor relationship. The maximum likelihood method was employed with a Promax rotation. Sixty items were removed from
the model, based on the following predetermined criteria. Indices were removed from the model if they did not have primary factor loadings that were ≥ .35, or if the items loaded on more than one factor. A summary of the analysis and the names of each factor is presented in Table 3.

Table 3. Summary of Items and Factor Loadings for Promax Solution for Listening Strategy Questionnaire

<table>
<thead>
<tr>
<th>Item</th>
<th>Factor loading</th>
<th>Factor loading</th>
<th>Factor loading</th>
<th>Factor loading</th>
<th>Communality</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 When listening to a difficult passage, I identify chunks of words, or phrases, rather than single words.</td>
<td>.85</td>
<td>-.02</td>
<td>-.01</td>
<td>.04</td>
<td>0.73</td>
</tr>
<tr>
<td>20 When conversing in English, I identify chunks of words, or phrases, rather than single words that the other person says.</td>
<td>.79</td>
<td>.10</td>
<td>.18</td>
<td>-.12</td>
<td>0.73</td>
</tr>
<tr>
<td>8 I judge how well I was able to understand the other person’s speech.</td>
<td>.47</td>
<td>-.17</td>
<td>.14</td>
<td>.16</td>
<td>0.31</td>
</tr>
<tr>
<td>23 I use knowledge of English stress and intonation to help me figure out words spoken unclearly.</td>
<td>.36</td>
<td>.29</td>
<td>-.05</td>
<td>-.06</td>
<td>0.26</td>
</tr>
<tr>
<td>4 I guess the meaning of unknown words by noticing the speaker’s tone of voice.</td>
<td>.00</td>
<td>.82</td>
<td>.10</td>
<td>-.30</td>
<td>0.67</td>
</tr>
<tr>
<td>5 I guess the meaning of unknown words by noticing the gestures, actions, or facial expressions of the speaker.</td>
<td>-.13</td>
<td>.65</td>
<td>.16</td>
<td>.13</td>
<td>0.50</td>
</tr>
<tr>
<td>19 When listening to a passage in class, I pay attention to my feelings about the passage.</td>
<td>.03</td>
<td>.45</td>
<td>-.07</td>
<td>.22</td>
<td>0.29</td>
</tr>
<tr>
<td>18 When listening to a difficult passage outside of class, I group words and expressions together based on common features.</td>
<td>.29</td>
<td>.40</td>
<td>-.33</td>
<td>-.04</td>
<td>0.33</td>
</tr>
<tr>
<td>10 I use personal experience to understand the speaker’s meaning and intentions.</td>
<td>-.03</td>
<td>.05</td>
<td>.76</td>
<td>.04</td>
<td>0.61</td>
</tr>
<tr>
<td>11 I use my knowledge of the world to understand the speaker’s meaning and intentions.</td>
<td>.24</td>
<td>-.07</td>
<td>.52</td>
<td>-.16</td>
<td>0.31</td>
</tr>
<tr>
<td>7 I guess the speaker’s intentions by noticing the gestures, actions, or facial expressions of the speaker.</td>
<td>-.11</td>
<td>.33</td>
<td>.51</td>
<td>.10</td>
<td>0.47</td>
</tr>
<tr>
<td>12 I use my knowledge learned from school to understand the speaker’s meaning and intentions.</td>
<td>.29</td>
<td>-.10</td>
<td>.41</td>
<td>.11</td>
<td>0.34</td>
</tr>
<tr>
<td>2 I listen to the other person’s speech to determine if he/she has understood me correctly.</td>
<td>-.01</td>
<td>.04</td>
<td>-.08</td>
<td>.63</td>
<td>0.37</td>
</tr>
<tr>
<td>22 I mentally prepare to listen by reviewing what I know and don’t know about the topic.</td>
<td>.13</td>
<td>-.06</td>
<td>.05</td>
<td>.61</td>
<td>0.45</td>
</tr>
<tr>
<td>14 I figure out the relationship between events when listening to a passage.</td>
<td>.14</td>
<td>.30</td>
<td>-.04</td>
<td>.59</td>
<td>0.61</td>
</tr>
<tr>
<td>17 When studying outside of class, I make sure to choose listening passages/materials that I like.</td>
<td>-.15</td>
<td>-.15</td>
<td>.06</td>
<td>.42</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Factor correlations

<table>
<thead>
<tr>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
<th>Factor 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>-.38</td>
<td>.50</td>
<td>-.56</td>
<td>-.41</td>
</tr>
<tr>
<td>-.26</td>
<td>.24</td>
<td>.26</td>
<td>.15</td>
</tr>
<tr>
<td>-.35</td>
<td>.24</td>
<td>.41</td>
<td>.26</td>
</tr>
</tbody>
</table>

Note. N=76. Boldface indicates highest factor loadings. Cronbach’s alpha = .71. Description of items is found in Appendix. Factor 1 = Global Understanding Strategies; Factor 2 = Paralinguistic and Grouping Strategies; Factor 3 = Knowledge and Experience-Based Strategies; Factor 4 = Learning Strategies.

Regarding RQ2, intercorrelations for scores are examined between the four factors of listening strategies and the calculated scores of each parameter. In addition to the parameters given above, the final score of the match is also included in the parameter. The results of our Spearman’s correlation test are given in Table 4, along with the scatter plots.
Table. 4 Intercorrelations Between Listening Strategies and Learning Behaviors

<table>
<thead>
<tr>
<th>Task 1 (Medium length/Difficult)</th>
<th>Seek</th>
<th>Start-Stop</th>
<th>Back</th>
<th>Forward</th>
<th>Between</th>
<th>Change SPD</th>
<th>Complete</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor1: Global Understanding Strategies</td>
<td>.07</td>
<td>.00</td>
<td>-18</td>
<td>-11</td>
<td>.03</td>
<td>.00</td>
<td>.224*</td>
<td>.11</td>
</tr>
<tr>
<td>Factor2: Paralinguistic and Grouping Strategies</td>
<td>.04</td>
<td>.09</td>
<td>.00</td>
<td>-10</td>
<td>-.06</td>
<td>.10</td>
<td>.09</td>
<td>-09</td>
</tr>
<tr>
<td>Factor3: Knowledge and Experience-based Strategies</td>
<td>-.07</td>
<td>-.05</td>
<td>-.08</td>
<td>-10</td>
<td>.04</td>
<td>-.01</td>
<td>.11</td>
<td>.12</td>
</tr>
<tr>
<td>Factor4: Learning Strategies</td>
<td>.04</td>
<td>-.19</td>
<td>-.225*</td>
<td>-.02</td>
<td>.04</td>
<td>.15</td>
<td>.14</td>
<td>.16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Task 2 (Medium length/Easy)</th>
<th>Seek</th>
<th>Start-Stop</th>
<th>Back</th>
<th>Forward</th>
<th>Between</th>
<th>Change SPD</th>
<th>Complete</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor1: Global Understanding Strategies</td>
<td>-.04</td>
<td>-.09</td>
<td>-.10</td>
<td>.09</td>
<td>.07</td>
<td>-.04</td>
<td>-.02</td>
<td>-.08</td>
</tr>
<tr>
<td>Factor2: Paralinguistic and Grouping Strategies</td>
<td>.10</td>
<td>.14</td>
<td>.11</td>
<td>.02</td>
<td>-.07</td>
<td>.00</td>
<td>.10</td>
<td>.01</td>
</tr>
<tr>
<td>Factor3: Knowledge and Experience-based Strategies</td>
<td>.10</td>
<td>.03</td>
<td>.10</td>
<td>.08</td>
<td>.01</td>
<td>.02</td>
<td>.07</td>
<td>-.05</td>
</tr>
<tr>
<td>Factor4: Learning Strategies</td>
<td>-.08</td>
<td>-.233*</td>
<td>-.236*</td>
<td>.01</td>
<td>-.03</td>
<td>.10</td>
<td>-.04</td>
<td>-.04</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Task 3 (Short length/Easy)</th>
<th>Seek</th>
<th>Start-Stop</th>
<th>Back</th>
<th>Forward</th>
<th>Between</th>
<th>Change SPD</th>
<th>Complete</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor1: Global Understanding Strategies</td>
<td>.09</td>
<td>-.04</td>
<td>.04</td>
<td>.09</td>
<td>.12</td>
<td>-.02</td>
<td>-.06</td>
<td>.00</td>
</tr>
<tr>
<td>Factor2: Paralinguistic and Grouping Strategies</td>
<td>-.06</td>
<td>.02</td>
<td>.02</td>
<td>.11</td>
<td>.01</td>
<td>.223*</td>
<td>.04</td>
<td>.223*</td>
</tr>
<tr>
<td>Factor3: Knowledge and Experience-based Strategies</td>
<td>.07</td>
<td>-.06</td>
<td>.10</td>
<td>.05</td>
<td>.17</td>
<td>.11</td>
<td>-.07</td>
<td>.06</td>
</tr>
<tr>
<td>Factor4: Learning Strategies</td>
<td>.04</td>
<td>-.05</td>
<td>-.02</td>
<td>.09</td>
<td>.01</td>
<td>.02</td>
<td>-.07</td>
<td>.06</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Task 4 (Very long/Difficult)</th>
<th>Seek</th>
<th>Start-Stop</th>
<th>Back</th>
<th>Forward</th>
<th>Between</th>
<th>Change SPD</th>
<th>Complete</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor1: Global Understanding Strategies</td>
<td>.13</td>
<td>-.07</td>
<td>-.10</td>
<td>.14</td>
<td>.12</td>
<td>-.16</td>
<td>.03</td>
<td>.00</td>
</tr>
<tr>
<td>Factor2: Paralinguistic and Grouping Strategies</td>
<td>-.02</td>
<td>.10</td>
<td>.04</td>
<td>.13</td>
<td>.03</td>
<td>.16</td>
<td>.15</td>
<td>.25*</td>
</tr>
<tr>
<td>Factor3: Knowledge and Experience-based Strategies</td>
<td>.00</td>
<td>-.10</td>
<td>-.04</td>
<td>.04</td>
<td>.05</td>
<td>-.05</td>
<td>-.03</td>
<td>.01</td>
</tr>
<tr>
<td>Factor4: Learning Strategies</td>
<td>.07</td>
<td>-.21</td>
<td>-.17</td>
<td>.07</td>
<td>.05</td>
<td>-.06</td>
<td>.00</td>
<td>-.10</td>
</tr>
</tbody>
</table>

*Note. *: r > .02

The result is not an optimistic one, since it is clear that the number of items showing a correlation is small, and their effect sizes are also rather small. However, there are some possibilities of correlations between the learning strategies and log data. It makes sense to assume there are other complex mechanisms underlying the learner’s factors, and we should include more items that might affect the correlation.
4. Conclusions and Pedagogical Implications

This study attempted to explore the possibility of a correlation between learning strategies and log data in dictation training courseware. Starting with a review of the importance of dictation tasks and listening strategies, the need to relate pedagogical constructs with learning analytics was stressed. However, the results obtained here are not clear. The finding in the above table that there is a weak negative correlation between start/stop frequency and learning strategies is interesting. The behavior of repetition could reflect compensation for the weakness of top-down processes, in accordance with previous studies by Field (1999) and other researchers. Longitudinal studies including more psychosocial factors are necessary for future research, to promote LA-based adaptive/personalized learning models along the lines of Xie, Chu, Hwang, and Wang (2019).

Acknowledgements

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References

Appendix. *List of Question Items for Listening Strategies in this Study*

1. I pay attention to the main points of the conversation in English to get a general understanding of what is said.
2. I listen to the other person’s speech to determine if he/she has understood me correctly.
3. I guess the meaning of unknown words or expressions by noticing redundant words or phrases with similar meaning.
4. I guess the meaning of unknown words by noticing the speaker’s tone of voice.
5. I guess the meaning of unknown words by noticing the gestures, actions, or facial expressions of the speaker.
6. I guess the speaker’s attitude toward the topic of discussion by noticing redundant words or phrases with similar meaning.
7. I guess the speaker’s intentions by noticing the gestures, actions, or facial expressions of the speaker.
8. I judge how well I was able to understand the other person’s speech.
9. I pay attention when the speaker communicates new or important information by noticing the intonation or stress on words.
10. I use personal experience to understand the speaker’s meaning and intentions.
11. I use my knowledge of the world to understand the speaker’s meaning and intentions.
12. I use my knowledge learned from school to understand the speaker’s meaning and intentions.
13. I pay attention to English words or expressions that are similar to Japanese words or expressions.
14. I figure out the relationship between events when listening to a passage.
15. When listening to texts, I use the title to guess the content or main idea of what I will hear.
16. When studying outside of class, I pay attention to my feelings about the listening passage.
17. When studying outside of class, I make sure to choose listening passages/materials that I like.
18. When listening to a difficult passage outside of class, I group words and expressions together based on common features.
19. When listening to a passage in class, I pay attention to my feelings about the passage.
20. When conversing in English, I identify chunks of words, or phrases, rather than single words that the other person says.
21. When listening to a difficult passage, I identify chunks of words, or phrases, rather than single words.
22. I mentally prepare to listen by reviewing what I know and don’t know about the topic.
23. I use knowledge of English stress and intonation to help me figure out words spoken unclearly.
Learning Support through Personalized Review Material Recommendations

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Abstract: Recent enrichment of digital learning environments has made it possible to obtain learning logs (data) on learners' learning behavior. In this situation, it is possible to recommend learning contents which are appropriate for individual learner by analyzing learning data. Our study develops a learning support system which recommends personalized review materials based on the results of quizzes and learning activities recorded by e-textbooks. In this paper, we explain the details of the system and report experimental results.

Keywords: learning support system, review material recommendation, adaptive learning

1. Introduction

The digital learning environment has been enriched with the recent development of information technology. In recent times, online platforms such as MOOCs offer a wide variety of learning content and opportunities for many people to learn. In addition, even at universities, online lectures using electronic devices are becoming more and more common. For example, an e-book system could be used to provide lecture materials, and a learning management system is capable of conducting quizzes and collecting students’ reports at the university level. By integrating these systems, we can expect to realize an advanced supporting strategy for enhancing students’ learning (Flanagan, 2017).

Similar to traditional learning, online learning methods often include quizzes on content after learning about a topic (section, subsection, or part) to assess students’ understanding. These assessments help students to reflect on what they have learned and estimate their learning progress (Khushboo, 2020). One effective way to compensate for the knowledge deficits revealed by the assessment is to recommend learning materials relevant to the content. Studies have been conducted on recommending learning contents (Konstantin, 2018; Ai, 2019). The majority of these studies on recommending learning content assume that students’ overall progress is good and focus on recommending what students should do next; they do not take into account the need for review. However, some students fail after learning a topic only once because they do not understand it well enough. Such students need to review material; however, some students are unable to do so due to lack of ability or motivation. For such students, supporting the review process with a learning support system is effective. For example, one possibility is to suggest some specific pages in the textbook that are presumed to be poorly understood.

The purpose of this study is to provide adaptive review support for individual learning comprehension by using a university online system-based lecture as a testing environment. In this study, it is assumed that students learn with e-textbooks and take a quiz at the end of the topic. We propose a learning support system that provides personalized review materials by identifying specific pages in the e-textbook that are presumed to have been met with low comprehension based on individual learning activities including quiz results. In the following section of this paper, we introduce the configuration of the proposed system as well as each method.

2. System

The purpose of this study is to support learning by developing an adaptive recommendation system for review materials. An overview of the system is shown in Figure 1. The system consists of Moodle, a well-known learning management system (Dougiamas, 2004), an e-book system, a database, and a
dashboard. The system flow is described as follows. First, students study a certain topic using e-textbooks. When a student uses any of the functions of the e-book system (such as open an e-textbook, go to the next page, highlight, etc.), e-book event logs are automatically recorded in the database. Students then take quizzes to check their proficiency on the topic on Moodle, and the quiz results are stored in the database. Then, based on the data collected from each student’s quiz results and e-book event logs, personalized review materials are recommended on the dashboard. In the following sections, we will describe the details of the proposed system.

![Figure 3. System configuration](image)

2.1 e-book-system

We use an e-book system called BookRoll (Ogata, 2015). After uploading e-textbooks in .PDF format to BookRoll, students can view the e-textbooks via a web browser. BookRoll has various functions such as adding a memo or a marker to a current page, evaluating whether a student understands the current page, and so on. As mentioned above, when a student uses any of the functions of BookRoll, e-book event logs are automatically recorded in the database.

2.2 Recommendation Methodology for Review Materials.

This system assumes that students learn a topic with the e-textbook and then take a quiz to check their proficiency at the end of the topic. It is common for students to fail to reach a target level of understanding after studying a textbook once. Therefore, this system identifies pages in the e-textbook that are poorly understood and presents them as content to be relearned. However, even if only the target page is presented within the scope of the textbook prepared in advance, there is a possibility that the learning may not be sufficient. Thus, our system also recommends websites related to the target page for further understanding. In the following sections, we describe how to identify pages associated with a low level of understanding, and then we describe how to get the URLs of websites related to the target pages.

2.2.1 Use of Quiz Results

One way to identify pages of low comprehension is to extract the specific pages in the e-textbook that are relevant to the content of the quiz that was incorrectly answered. In this case, it is necessary to link the relevant pages of the e-textbook to each question on the quiz. Although it is possible for teachers to register the related pages in advance, it is not practical for teachers to register the related pages every time a quiz is created. Therefore, our system uses an approach (Ishikawa, 2020) that automatically retrieves related pages using text information. The following is a method for retrieving the pages in an electronic textbook that are related to a quiz.
First, we vectorize the question texts and answer texts in a quiz as follows.

1. Extract n words from the quiz questions, answer sentences, and obtain the word set \( T_p = \{ t_1, t_2, \ldots, t_i, \ldots, t_n \} \).

2. Convert each of the n words in \( T_p \) to a vector \( \mathbf{v}_{t_i} \) using Word2Vec (Mikolov, 2013). Since we deal with Japanese texts, we use an existing Word2Vec model created from the Japanese Wikipedia (Suzuki, 2018) and transform n words into 200-dimensional vectors \( \mathbf{v}_{t_i} \).

3. Add all the vectors generated in the previous step and divide by the number of words n to normalize the data (formula (1)).

\[
\mathbf{v}_q = \frac{\sum_i \mathbf{v}_{t_i}}{n} \quad (t_i \in T_q) \quad \ldots (1)
\]

In this way, we can represent a quiz as a 200-dimensional vector \( \mathbf{v}_q \).

Next, in the same way, we vectorize the e-textbook page by page, as follows.

1. Extract n words from the text on a page and obtain the word set \( T_p = \{ t_1, t_2, \ldots, t_i, \ldots, t_n \} \).

2. Considering the text on a page as a document, calculate the value of TF-IDF (Ramos, 2003) for each of the n words in \( T_p \).

3. Each of the n words in \( T_p \) is transformed into a vector \( \mathbf{v}_{t_i} \) using a 200-dimensional pre-trained Word2Vec model.

4. Add up all the vectors of the previous step. In this case, a weighted average is performed with the TF-IDF value of step2 (formula (2)).

\[
\mathbf{v}_p = \frac{\sum_i \text{TF-IDF}(t_i) \mathbf{v}_{t_i}}{\sum_i \text{TF-IDF}(t_i)} \quad (t_i \in T_p) \quad \ldots (2)
\]

In this way, we can represent pages in an e-textbook as a 200-dimensional vector \( \mathbf{v}_p \).

Finally, the relevant pages of quiz \( q_i \) can be extracted from the e-textbook using the following procedure.

1. Compute the cosine similarity between the feature vector of \( q_i \) and the feature vector of each page.
2. The pages are ranked in order of cosine similarity, and the page with the higher score is considered to be related to \( q_i \).

2.2.2 Use the Function of the e-book System

There are two response buttons, “got it” and “didn’t get it,” on the screen of the e-book-system as a function of BookRoll. Each student can evaluate whether or not they have understood the current page by clicking one of the two buttons when viewing e-textbook. The click information of these buttons is stored in the database as a log. This system simply utilizes this log and presents the pages where the “didn’t get it” button was pressed as pages with low levels of understanding. In addition, the number of students who clicked the “didn’t get it” button when using an e-textbook are tallied. The top four pages with the most clicks of this button are presented as review materials.

2.2.3 Page-wise Website Recommendation

This system also presents URLs of websites related to each page extracted by the method described in 2.3.1 or 2.3.2. Relevant websites can be retrieved by using the text mining method described in (Nakayama 2019, 2020). This method provides an appropriate learning environment that helps learners find appropriate knowledge objects within the vast amount of information on the Internet. Finally, we obtain five URLs for each page and present them.

2.3 Dashboard

We developed a dashboard for providing review materials. The dashboard can be used by clicking on the link in Moodle. This dashboard provides the following three functions, including the function to provide review materials.

- Reflection on the results of the quiz
• Checking e-textbook reading time
• Provision of review materials

In this way, we developed this dashboard not only to present review materials, but also to help students reflect on their own learning. The dashboard screen is shown in Figure 2. Figure 2-(A) is a web page for selecting the topic students want to review. When the selection is complete, they click a green button. Figure 2-(B) is the screen after the selection. The three function screens are shown in an accordion format and are minimized at first. Figure 2-(C) shows the reflection of the results of the quiz. The user’s score and the average score of the other students are displayed in the upper left corner. The overall score distribution is shown as a graph. In addition, users can check the questions, answers, and correctness of the quiz. Figure 2-(D) shows how to check the amount of time students using the dashboard have spent reading the e-textbook. The reading time per page is shown as a graph. The horizontal axis is the page number of the e-textbook, and the vertical axis is the reading time. Figure 2-(E) presents the review materials. This function is initially closed in an accordion form. As mentioned in section 2.3, these materials comprise (1) the top four pages related to the quiz question with the incorrect answer, (2) the pages where the “didn’t get it” button was clicked, and (3) the top four pages with the most clicks on the “didn’t get it” button. If (1) or (2) is not present for the user, it is not displayed. Figure 2-(F) shows the screen for viewing the review materials. The target page is on the left side, and the URLs of the related websites are shown on the right side of the page. When reviewing a textbook, it may be necessary to check not only the specific page, but also the flow of the textbook before and after the target material. Therefore, we made it possible to display the previous page and the next page by clicking the gray triangle below the target pages. In addition, the image of the page is enlarged when users hover their mouse over it.

3. Experiment

We conducted an experiment to evaluate the usefulness of the proposed system. Participants were students who took a “cyber security” course at Kyushu University in the spring semester of 2020. There were 101 students in this course. The first part of the experiment was a pre-questionnaire to investigate the students’ attitudes toward online learning. This questionnaire was answered by 83 students. After the course, we then sent an email to the students to encourage the use of the dashboard for review; 33 of the 101 students used the dashboard. Note that the use of the dashboard was optional, and the usage rate was about 30%, which is high considering the fact that the link click rate on email about higher education is around 7% (Constant Contact, 2020). We further asked system users to answer a questionnaire about their impressions of the dashboard. Altogether, 22 students responded to the
questionnaire. Both questionnaires were scored on a 5-point scale. Below, we will report on the trends of students using the system, the results of the system questionnaire, and the usage status of the system.

To first determine what trends students have used the system, we divided 83 students into two groups: system users and others, and we compared the results of the pre-questionnaire. In the pre-questionnaire, students were asked the following three questions about online lectures to see if they felt comfortable with their learning. “PQ1: Are you worried about the learning method?” “PQ2: Is it difficult to understand the content only using the lecture?” and “PQ3: Are you learning properly at your own pace?” If students are confident in their learning, we can assume that PQ1 and PQ2 would be low and PQ3 would be high. The average scores of the two groups for these three questions are shown in Table 1. The Wilcoxon rank sum test (a nonparametric statistical test) was also performed between the two groups. In the test, PQ1 was significantly different (p<0.01), while PQ2 (p=0.135) and PQ3 (p=0.243) were not significantly different. However, as shown in Table 1, system users tended to have higher scores on PQ1 and PQ2 and lower scores on PQ3. Considering the results, system users were relatively confident and system non-users tended to have less confidence in their learning. This may mean that more motivated students used the system.

Table 1. Pre-questionnaire comparison results

<table>
<thead>
<tr>
<th></th>
<th>PQ1</th>
<th>PQ2</th>
<th>PQ3</th>
<th>Total number of students</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>System Users</strong></td>
<td>2.97 ± 1.17</td>
<td>3.67 ± 0.87</td>
<td>4.20 ± 0.98</td>
<td>33</td>
</tr>
<tr>
<td><strong>System non-users</strong></td>
<td>3.83 ± 1.28</td>
<td>3.91 ± 1.19</td>
<td>3.98 ± 1.36</td>
<td>50</td>
</tr>
</tbody>
</table>

Table 2 shows the contents and results of the questionnaire. All questions in Table 2 were to be answered on a 5-point scale, where 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree. Q1 asked about the usefulness of each of the three functions of the system. Of the 22 respondents, respondents had a favorable evaluation of the usefulness of “Reflection on the results of the quiz” (“strongly agree” or “agree”). The evaluation of the usefulness of “Checking e-textbook reading time” function was inconsistent. This function simply showed a comparison between the students’ own reading time and the average time of the other students, but it seems that it was difficult for participants to judge whether it was useful just by looking at it. Of 22 respondents, 16 responded “strongly agree” or “agree” that the “Provision of review materials” function was useful. For Q2, the respondents were asked to look at the review materials presented to them and to rate whether the materials were useful for the review. Of the 22 participants, 19 responded positively. From the results, we can conclude that the proposed method provides useful review materials to some extent. In Q3, we asked if the participants would like to use this kind of dashboard for review in the future, and 20 of the 22 students responded positively. The positive evaluation in Q1 and Q2 may have led to this result.

Table 2. Questionnaire Results

<table>
<thead>
<tr>
<th></th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Q1</strong></td>
<td></td>
</tr>
<tr>
<td>Were the following three functions of the dashboard useful?</td>
<td>1</td>
</tr>
<tr>
<td>Reflection on the results of the quiz</td>
<td>1</td>
</tr>
<tr>
<td>Checking e-textbook reading time</td>
<td>1</td>
</tr>
<tr>
<td>Provision of review materials.</td>
<td>1</td>
</tr>
<tr>
<td><strong>Q2</strong></td>
<td></td>
</tr>
<tr>
<td>Do you think the content presented as review material would be useful for your review?</td>
<td>0</td>
</tr>
<tr>
<td><strong>Q3</strong></td>
<td></td>
</tr>
<tr>
<td>Do you want to use this kind of dashboard in the future?</td>
<td>0</td>
</tr>
</tbody>
</table>
Finally, we investigated how students used the system. On average, the system users selected 4.8 out of 8 topics in the course to view the review materials. Thus, we can assume that they used the system to some extent. In addition, the analysis of the system usage time showed that shorter users worked with the system for less than 1 minute and longer users worked with the dashboard for approximately 10 minutes. From these results, at least, review activities were triggered by the proposed system, and some students utilized the recommended materials for positive usages. Meanwhile, we have to consider another effective recommendation strategy for taking care of the other students. Given the results of the questionnaire, we think there is ample room for students to accept this system.

4. Conclusion and Future Work

In this paper, we proposed a system for recommending review materials based on the results of quizzes and the functions of e-textbooks. We conducted an experiment using the developed recommender system. As a result of the analysis of the questionnaire, we obtained positive responses about the use of the system. However, a voluntary usage experiment revealed that students who were relatively more anxious about their learning were less likely to use our system. Furthermore, analysis of the use of the system showed that few students were using it for full-scale review. Therefore, it will be necessary to improve the system so that it is properly utilized to support all students, including those who are anxious about their learning. There are several other challenges for the future. First, we are going to expand our recommended review materials to include more than just e-textbooks and websites. Second, a more detailed analysis of the learning behavior of the system users is needed to improve the efficiency of learning improvement. Therefore, we would like to improve the design of the dashboard to be able to track the students’ learning behavior in more detail. Third, we would like to investigate how the system can positively affect the learners with a long-term experiment.

Acknowledgements

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ENaCT: An Action-based Framework for the Learning and Analytics of Critical Thinking

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Abstract: Critical thinking (CT) is an important 21st-century skill. In this paper we propose a new framework – Embodied Narratives of Critical Thinking (ENaCT) – to conceptualise the learning of CT, as well as analytics to assess CT, in a technology-enhanced environment. In the context of a CT activity, this position paper bridges the perspectives of embodied cognition, aligning actions that constitute learning, with learning analytics approaches, to measure and build embodied narratives of the learning process. We illustrate the components of this new framework through a preliminary interface design conceptualised for the learning of CT within an online reading platform. Applicability of the framework and future research agenda are discussed.

Keywords: Critical Thinking, Learning Analytics, 21st Century Skills, Embodied, 4E cognition

1. Introduction

Educators all over the world agree that critical thinking (CT) is one of the core 21st-century skills. Scholars conceptualise CT as either a skill (Paul & Binker, 1990; Paul & Elder, 2008) or a process (Jeevanantham, 2005). There exist several definitions of CT. For instance, according to Paul & Elder (2008), CT is characterised as the skill to analyse and evaluate thinking with a view to improve it; in other words, CT is self-directed, self-disciplined, self-monitored, and self-corrective thinking. Alternately, CT has been described as requiring high-order thinking and involving the processes of analysis, evaluation, reasonableness, and reflection (Jeevanantham, 2005). A well-cultivated critical thinker raises vital questions and problems, formulates them clearly and precisely, gathers and assesses relevant information, uses abstract ideas to interpret it effectively, comes to well-reasoned conclusions and solutions, and tests them against relevant criteria and standards. In addition, a critical thinker thinks open-mindedly within alternative systems of thought, recognising and assessing, as need be, their assumptions, implications, and practical consequences, and communicates effectively with others in figuring out solutions to complex problems (Paul & Elder, 2008).

Currently, CT is assessed using standardised tests or rubrics for open-ended activities. Some examples include the California Critical Thinking Skills Test (Facione, 1990), the Cornell Critical Thinking Tests (Ennis & Millman, 2005), the Ennis-Weir Critical Thinking Essay Test (Ennis & Weir, 1985), and the Watson-Glaser Critical Thinking Appraisal (Watson & Glaser, 1980). Researchers have also used rubrics in order to assess student performance on open-ended tasks or domain-specific measures of CT (Tiruneh et al, 2014; Mutakinati et al, 2018). Rubrics are designed based on the universal intellectual standards of Paul and Elder (2008).

Recently, researchers are also using learning analytics in order to measure and model complex thinking skills such as CT, engineering design, and decision making (Shum & Crick, 2012; Blikstein, 2011; Biswas et al, 2019; Vieira et al, 2016; Xing et al, 2019). Learning analytics can enhance, and be supported by, traditional educational data analysis methods. In particular, learning analytics methods employ learner trace data from learning environments to generate models of learners, predict learner
performance, and adapt learning designs to better suit learning requirements (Biswas, et al., 2019; Moreno-Marcos, et al., 2020; Hernández-Leo, et al., 2019). However, in order to establish the reliability and validity of trace data analytics, and to make causal inferences about learning from these data, it is necessary to ground the analysis in the pedagogical theory of the domain (Winne, 2020) as well as cognitive accounts of the process of learning (Biswas, et al., 2019; Worsley & Blikstein, 2014). Such theoretically grounded learning analytics have not been done for critical thinking learning data.

In this work, we present an integrated conceptual and analytics framework which guides the evaluation and learning design for CT. This framework, informed by embodied accounts of thinking, cognition, and learning, will allow us to streamline learning analytics in order to measure theory-based markers of good CT performance from the collected data traces.

2. Related Work

2.1 Critical Thinking

The literature on teaching-learning of CT predominantly comprises contributions from three different schools of thought - Philosophy, Psychology, and Education (Lai, 2011). While there are significant differences between the three on what constitutes CT, they agree on three key ideas related to CT - the need for personal dispositions, the key abilities to be exhibited by the learner, and the importance of background knowledge (Ennis, 1985; Halpern, 1998; Bailin et al., 1999; Facione et al., 2000). Dispositions are broadly defined as attitudes or habits of mind, whereas the abilities involve actions that require learners to use higher-order thinking (e.g. analysing arguments or claims, making inferences, judging or evaluating situations, making decisions, or solving problems). Domain-related background knowledge is considered essential to CT as evaluations and decisions one makes will have a strong bearing on the domain. Paul and Elder’s (2001) ‘Elements of Thought’ provides an objective framework for investigating CT skill and underlying processes. According to Paul and Elder’s model, all thinking consists of eight basic structures (elements of thought). These include, an understanding of, and an ability to, formulate, analyse, and assess: (i) the purpose (or significance) of a problem/activity, (ii) the questions at issue, (iii) presented/available information with respect to the context, (iv) problem-relevant concepts, (v) (one’s own) interpretations of the above and inferences based thereupon, (vi) one’s assumptions, (vii) implications and consequences of the output of the activity, and (viii) one’s point(s) of view (Figure 1). An uncritical thinker, according to this model, has less command on these elements of thought (Paul & Elder, 1999).

Figure 1. Elements of thought, reproduced from Paul & Elder (2019)
Existing assessments of CT skills are broadly reliant on standardised tests or rubrics for assessing open-ended activities. The California Critical Thinking Skills Test (CCTST), for instance, was devised to assess the development of CT as a part of an academic curriculum designed to improve CT among undergraduate students (Faicone, 1990). The Cornell Critical Thinking Tests collection is another example of multiple-choice tests that measure “general” CT abilities (Ennis, 1993). The Ennis-Weir Critical Thinking Essay Test (Ennis & Weir, 1985) and the Watson-Glaser Critical Thinking Appraisal (Watson and Glacer, 1980) are short-answer or essay type assessment questions. The Halpern Critical Thinking Assessment (HCTA; Halpern, 2010) consists of both multiple-choice and short-answer questions, and has a total of 25 everyday scenarios that respondents analyse and critique. HCTA measures five subcategories of CT skills: (i) verbal reasoning skills; (ii) argument analysis skills; (iii) skills in thinking as hypothesis testing; (iv) skills to utilise the concepts of likelihood and uncertainty; and (v) decision-making and problem-solving skills.

While all of these assessments are administered after CT learning-teaching interventions as post-tests, there are other subjective methods such as rubrics for more open-ended activities that help measure a learner’s CT skills. For instance, Mutakinati et al. (2018) utilise a four-level rubric, with four distinct criteria for evaluating open-ended assignments in a project-based learning setting. The authors also used this rubric to classify thinkers into six categories. The rubric is based on Paul and Elders’ (2001) framework of CT.

2.2 Embodied accounts of cognition and thinking

Traditional approaches to analysing the processes of thinking and reasoning (collectively, thinking skills) in technology-enhanced learning environments are predominantly grounded in the information processing theories of cognition (Majumdar et al., 2014; Pande & Chandrasekharan, 2017; Reynders et al., 2020). These approaches assert that a learner first engages in extraction of information from the content embedded in the learning environment (e.g. text, representations, models); the learner performs thinking or reasoning about ‘using’ this extracted information. Further, the ‘act’ of thinking or reasoning about is understood by these approaches as (i) symbolic transformation or translation performed on the extracted information, (ii) as taking place entirely inside the brain/skull, and (iii) as separate or dissociated from the actual content presented in the learning environment, as well as the actions/interactions one performs on this content. The learner’s body, and bodily actions (e.g. movements, gestures, interaction with the surroundings), in these approaches, are treated as a product of information-based thinking.

Newer approaches to cognition and learning (e.g. 4E cognition; Menary, 2010; Newen et al., 2018), however, treat actions as a critical part of the thinking process, and not merely as a product of thinking. For instance, distributed cognition-based investigations of problem-solving processes have shown how spontaneous (assumedly information seeking) actions in virtual environments (e.g. constantly rotating the incoming shapes through all possible orientations in Tetris) help offload parts of thinking (e.g. matching shape orientations and contours with increasing speed and accuracy), and the underlying cognitive processes (e.g. mental rotation), to elements in the external environment (e.g. controller keys, computer screen displaying the game as one plays it in real-time; Kirsh & Maglio, 1994; Kirsh, 2010). Empirical evidence also suggests that actions (e.g. highlighting text, sketching - processes traditionally deemed as outputs of thinking) facilitate the emergence/occurrence of newer ideas and insights during the processes of problem-solving and scientific discovery (Aurigemma et al., 2013). This indicates that actions feed back into, and reorganise and refine, thoughts.

Going one step further, embodied and enactive cognition approaches regard ones’ thinking, their actions, and the environmental elements being interacted with, as coupled together (Pande, 2020). For instance, Landy et al (2014) show, in the context of a technology-enhanced learning environment designed to support embodied learning of mathematical concepts, how mathematical symbols, the physical operations one performs on symbols, and the visible forms of relationships between those symbols, together constitute one’s mathematical thinking (for work on perceptual learning, also see Kellman & Garrigan, 2007; Landy & Goldstone, 2007; Pande & Chandrasekharan, 2020). In summary, these new approaches in cognitive science show that elements of (technology-enhanced) learning environments, and one’s bodily actions on those elements are not dissociated from thinking, as initially
considered, but rather are a part of the thinking and reasoning processes.

This revised understanding of thinking as an action-based or embodied activity has implications to designing for, and analysing, learning in interactive technology environments. Modern technologies allow diverse ways of presenting target content/concepts and/or their representations. These diverse presentations in turn afford novel body-based interactions between the learner and the elements of the learning environment. Given that body and actions affect thinking (by constituting it; e.g. Landy et al., 2014), technology-enhanced learning environments could be designed to include novel affordances (and related interactions) to facilitate more ‘desired’ forms of thinking (e.g. CT or its components) among learners. Similarly, learner actions/interactions within such environments in relation to their affordances could be analysed to understand and/or generate models of the thinking processes, and learners, as well as to investigate the effectiveness of the learning environment designs.

2.3 Learning Analytics

Recent research in learning analytics aims to model and analyse complex 21st-century competencies in order to support traditional educational data analysis (Shum & Crick, 2016). The goal is to model student behaviour as they do complex thinking tasks such as decision making, programming, and engineering design, in technology-enhanced learning environments, in order to improve assessment and performance prediction, as well as to provide feedback to learners (e.g. Blikstein, 2011; Biswas et al, 2019; Vicira et al, 2016; Xing et al, 2019). In this approach, learners’ actions in learning environments (such as their use of certain resources, artefact creation, reading, typing) are captured. Machine learning methods are then applied to the captured action-data in order to identify sequences or clusters of actions, and correlate these patterns with student performance on tasks. These patterns and correlations help build a learner model. The learner model can then be used to make predictions and adapt instruction. The underlying assumption here is that the action patterns of a learner say “something” about their performance on the task.

When these analyses are grounded in a theoretical framework of the domain, such as the above-described embodied accounts of thinking, wherein bodily actions are constitutive of thinking, these clusters or sequences can be used to make causal inferences about learner performance on tasks (Winne, 2020). The theoretical grounding increases the validity and reliability of learning analytics. However, there is a dearth of research into building embodied or action-based learner models, especially for CT tasks. Therefore, a primary goal of our work is to develop an integrated conceptual framework that brings together learner modeling and CT acquisition, within the theoretical framework of embodied cognition.

3. ENaCT Framework

We propose a framework that integrates the process of acquisition of CT (the learning aspect), and the process of data-based modelling of a critical thinker or a CT learner (analytics aspects). As discussed earlier, most conceptual and analytics approaches to CT, being implicitly or explicitly grounded in the information processing accounts of mind, tend to treat CT as dissociated from one’s bodily actions, and one’s tendencies or patterns of navigation through a (task) context/environment. To address this major limitation, we focus on an individual’s actions performed during learning or problem solving, in the context of CT. For this new action-based (embodied) framework, we use Paul and Elder’s (2019) elements of thoughts’ model (see figure 1 in section 2.1), which provides a comprehensive set of possible (cognitive) tasks involved in executing or learning CT.

Figure 2 shows the new Embodied Narratives of Critical Thinking (ENaCT) Framework. As indicated earlier, our framework has two components: a conceptual component modelling how artefacts in one’s environment, and the bodily interactions one has with those artefacts, relate to learning and execution of a skill (e.g. CT); and an analytics component modelling how artefacts and actions could help generate assessments or models of the learner. In the first conceptual component, we consider that problem solving or learning happens when an individual interacts with the given system affordances,
and executes actions. Learning scaffolds are specific sets of affordances either embedded within the learning environment or provided externally. Scaffolds are primarily designed for assisting the process of learning. The system affordances should be designed with inputs from the specific thinking task model that outlines how different (bodily) actions of an individual constitute the application or execution of one or more elements of thought. In addition to interacting with the environment (e.g. a technology-enhanced learning environment), an individual can also create artefacts anytime during or at the end of the learning or problem-solving process. Such artefacts created at an intermediate stage of a process can themselves generate newer affordances, which can be further incorporated in the individual’s action space as one proceeds through problem solving, and/or support learning. Thus, as one keeps interacting with the affordances within that action space, different individuals can follow different pathways of problem-solving or learning. Through time, one may also further adapt themselves to incorporate newer pathways such as those generated by newer artefacts, in turn facilitating richer skill execution and learning (hence the bi-directionality of the connection in Figure 2).

In the second learner modelling component of the framework, the action space is logged as learner interactions in the learning environment together with learner generated artefacts. Similar to system affordances, learning analytics should also be informed by the specific thinking task model. The level of acquisition of the skill, and related behaviors, can be used to develop a learner model collectively based on the interaction and artefact generation log data.

Our approach thus does not consider one’s bodily actions in the environment and generated artefacts as products of critical thinking, particularly as we believe that the generated artefacts also generate newer affordances (and hence thinking possibilities) for the learner/problem solver. In this framework, one’s bodily actions, and the artefacts they generate, constitute CT similar to how a learner’s actions in ‘Graspable Math’ (Landy et al, 2014) constitute mathematical thinking. Moreover, we consider actions/interaction patterns as a part of one’s observable behaviour that could be linked to CT; however, in the conceptual components of the model, we deem actions as part of the critical thinking process - which is why observing them to model thinker/learner behaviour makes all the more sense.

**Figure 2. Embodied Narratives of Critical Thinking (ENaCT) Framework**

4. **Instantiation of the framework for a CT Task**
In this section, we elaborate on the ENaCT model with reference to the following CT task:

“As you already know, the novel coronavirus has spread all over the world, and different governments have given guidelines and rules for containing the spread of the virus. The school and policymakers in your region are discussing whether schools should run in a regular mode (all the students on campus/in the classroom), or hybrid mode (50% students attend physically, while the remaining attend via internet) or completely online mode. If you were the policymaker, what mode would you propose, and why?”

We envision that this task would be performed within a software environment with affordances designed as sub-tasks based on Paul and Elder’s Elements of Thought (Paul & Elder, 1999). The environment will provide learners the opportunity to explicitly ‘act on’ and practice each of these elements. Further, the environment would include information and conceptual resources in the form of interactive graphs, text, and videos which learners can use as they need while doing the task. The environment would be open-ended - no predetermined order/sequence of activities (pathway) would be imposed, and learning scaffolds would be available on demand. Within such an environment, the task model for critical thinking could be as shown in Figure 3.

![Figure 3. Task model for critical thinking activity](image)

From observable behaviours within the software learning environment, we could assess learner performance on the task and acquisition of CT skills. For instance, adding/modify entries in the ‘Purpose’ sub-task is one of the actions that is constitutive of the element of thought of “Purpose”. By identifying patterns in learner behaviour, such as “viewing graphs” followed by “modifying purpose”, we can gauge the level of learner behaviour. Further, by assessing the quality of generated artefacts (e.g. entries in the “Purpose” sub-task), we can assess one’s progress of learning (level of acquisition) of CT. Together, these analytics would help us build the learner model. The ENaCT framework adapted to this CT task model is shown in Figure 4.

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5. Implications and contribution

5.1 Approaches to the development of CT

As learners navigate through the software learning environment and do CT tasks, they use the affordances to solve problems and scaffolds to learn various aspects of the CT skill. From the embodied accounts of cognition and thinking, it follows that one’s (bodily) action patterns are representative of their level of performance on CT tasks, as well as their level of acquisition of CT skills. By measuring one’s performance using an independent CT test and rubric, and classifying the behaviours of good and poor critical thinkers, we can identify behavioural markers of good performance and learning on CT tasks. Further, these behavioural markers could be utilised to build a narrative of learning pathways/trajectories, possibly as a constitutive or causal account of how certain behaviours relate to one’s observed performance and learning (Rahaman et al, 2017).

5.2 Learning and Educational Technology Design

In section 4, we propose one possible instantiation of a technology-enhanced learning environment for CT. The ENaCT framework can be utilised for revising the design of learning activities and environments based on learning analytics. An individual’s performance scores and engagement, for instance, with individual elements of thought help in tracking their competencies on each aspect of CT, whereas individual scores aggregated together at any time can provide the level of overall CT skill acquired by a learner. These scores and the interaction behaviours of a learner help in further updating the learner model. The learner model generated in a specific context at a given time could be used to predict one’s task performance and engagement. Subsequently, interventions can be designed for adaptively (or intelligently) scaffolding the learning activity. For instance, by characterising the productive and unproductive behaviours of critical thinkers as described in section 5.1, we could adaptively present personalised scaffolds to learners based on whether their behaviours are productive or unproductive. If a learner is showing unproductive behaviours, we could provide them additional scaffolds to shift their behaviours towards being productive as done in adaptive tutoring systems (Chen et al, 2019).
5.3 Pedagogical Implications

We aim to design an online environment to foster learner CT skills by giving the learner a specific task context. Having a technology framework and model to extract data regarding skill acquisition behaviors could collectively inform teachers, facilitators and other stakeholders about the learner, and the process of learning. A valid and reliable indicator can thus help formatively assess the learner. Such an objective indicator would also serve as a self-assessment tool for the learner. Teachers can be supported in classroom orchestration of learning activities using dashboards that show (possibly, also real-time) performance indicators of students, which they can use to modulate their teaching by, for instance, initiating collaborations, personalising interventions, and debriefing (Holstein et al, 2020).

6. Conclusion

In this paper, we proposed a framework for building embodied accounts of CT, based on Paul and Elder’s (1999) CT task model. We proposed an approach to tracing CT skill as enacted within an online learning environment. In our conceptualisation, we explicitly considered the bodily actions that a learner performs, together with affordances of the online system as constitutive of the learner’s CT. Such a theoretical lens is missing in the CT learning and assessment literature. Our framework helps re-analyse the learning of CT in an interactive online learning environment. While our theoretical basis for the different aspects of the framework is solid, currently we have not conducted empirical studies to validate it. Our immediate future work involves implementing the instantiation described in section 4 and gathering data to validate/revise our framework. We hypothesise that such an intervention would lead to the development of an embodied narrative of the learning as well as learning analytics of critical thinking.

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References


Learning Analytics for Humanities and Design Education

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Abstract: Many Learning Analytics interventions are created and adopted in the context of STEM disciplines and medical education for in class and online learning. However, the focus of using a learning analytics platform for humanities and design related courses are still rare. This position paper focuses on the need of interdisciplinary work to bridge the humanities and design faculties with the learning analytics community and possible research agenda. We illustrate how the Learning Evidence Analytics Framework (LEAF) can be used to probe the learning processes in the context of the humanities and design related topics.

Keywords: Learning Analytics, LEAF, Humanities Education, Design Education, Critical Reading Activity, Sense making

1. Motivation

Learning analytics as a domain has evolved over the period and its techniques have been applied to understand the process of learning and supporting it in various e-learning contexts. The interdisciplinarity of such a domain can be based on the four realms: knowledge, research, education, and theory (Nissani 1997). While there are many studies which look at the different applications of Learning Analytics (LA) in STEM domains (Sergis et al. 2019) and medical education (Chan et al. 2018), the focus on humanities courses at the university level is still limited. Teaching modalities of humanities and design courses have adopted online learning. Currently nearly 338 courses on Coursera and 365 courses on EDx that are offered relate to the humanities and design disciplines. However the analytics used on such platforms are generic which is applied to all courses and intend to be scalable. We found a lack of systematic research to understand the learning objectives of Humanities and Design topics which are orchestrated within an elearning environment and then develop appropriate indicators which can be analysed to understand the learning process and assist it. Our LA-ReflecT project is positioned in that space.

2. Learning Analytics of Reflective Tasks (LA-ReflecT)

The LAReflecT project aims at developing a data-driven narrative of learner behaviors during any reflective tasks. It focuses on the context of Humanities and Design related topics. Such an investigation requires a well-designed activity plan with technology affordances to collect indicators of learning behaviors and then applying educational data mining techniques to model that specific context. This collaborative work brings in expertise from the domain of humanities and design studies and learning analytics.

To initiate, Learning Evidence Analytics Framework (LEAF) provides the overarching technology framework to collect evidence of learning behaviors from the logs generated in a technology-enhanced learning environment (Ogata et al. 2018). In our instantiation of the framework,
the instructor can coordinate the activity on Moodle, as the learning management system. BookRoll (Ogata et al. 2015), an e-book reader, is used to upload reading contents related to the learning activity such as reference articles and activity sheets in PDF format for students to access. Tools like BookRoll can be considered as a learning behavior sensor in the smart learning environment that log teacher’s and student’s interactions with the system (reading and annotations in case of BookRoll) in a Learning Record Store (LRS) as standard eXperience API (xAPI) statements. This log data from the learning environment, the artefacts created by the learners and any of their collected data for example surveys regarding pre-dispositions, perceptions or affect are analysed within the learning analytics framework, LEAF. Such an integrated data about context and the learner would assist to build models of the learning process and thereby design possible feedback and teaching learning support. Figure 1 presents an overview of our approach.

![Figure 1. Overview of the LA-ReflecT approach](image)

3. **Research Agenda : Humanities, Design and Learning Analytics perspectives**

From the Humanities education standpoint, developing critical reading skills is crucial (Holm et.al. 2015). Such an activity requires cognitive tasks such as comprehending, analyzing, evaluating, interpreting and synthesizing. A critical reading activity requires one to highlight important ideas in the text, relate it to one’s personal experiences, pose questions and think about answers for such questions, look into the patterns within the text, and make connections with other texts. In certain contexts, it would involve identifying socio-cultural contexts and reading through them. Critical reading enables the reader to read not only the explicit meanings but the layered and the implicit meanings as well. Over and above, critical reading enhances one’s ability for task-focused thinking. We conducted a pilot study where a learning task was identified to annotate cultural references and performative elements. Learning logs were gathered for analytics during that task to define the reader's profile in the context of the task (Majumdar et al. 2020). Of the four profiles identified, highly engaged readers validated that the annotation task given to them led them to read the text with more focus and analyze it properly as opposed to blindly reading it.

Similarly, in Design related topics too, focusing on developing a critical eye about analysing issues and proposing a design as a solution becomes an essential learning objective. Design, like humanities, often focuses on processes and not just the outcome. Also, the emphasis is not on the procedural knowledge, instead focus is on whether the learner is applying a set of design principles or not while maintaining their own style of design. For instance, graphic design is one of the common topics in the design domain. For the ease of analysis we take an example of a concept in Graphic design, which is: Designing a Logo. This is a common assignment which expects the learners to express their thinking through an unique design and analyse their choices relating to the principles justifying the communication works. Therefore, when the teacher announces the assignment to create a logo for a petroleum company, the learners can /will create different ‘looking’ submissions, which
could be based on ‘different’ theories/guidelines. The submissions may/may not have commonality of shapes, elements, colour, typography, etc. and that is perfectly fine.

In STEM domains, the learning environment often provides learning tasks with predetermined step-by-step problem solutions (Aleven and Koedinger, 2002). Recently open-ended learning environments developed in the science domain provides the learner with a complex problem and the tools and resources that are required to solve the problem (e.g. Betty’s Brain System, Biswas et al, 2016). Learning analytics have been applied to the data obtained from these environments to model learners and to provide personalised feedback, hints and content. In open-ended learning environments, there can be multiple paths (solution approaches) to solve the given complex problem. However, students’ knowledge can be compared with the expected solution and personalised feedback are provided.

In the humanities and design domain, the problems are solved using multiple solution paths and also there can be multiple correct solutions. Hence the traditional learning analytics approaches that are used in STEM domains might not be directly applied to problems in the humanities and design education domain. We would like to instantiate a multilevel learner modelling (Biswas et al, 2019) to develop a learner model in design problems. In this model, the students’ interaction with the learning environment is captured and learners’ cognitive skills and strategies will be measured. Based on learners’ interaction and performance on the learning task, the learner model will provide personalised feedback to support the learners.

Given such a context, in this workshop we plan to initiate a conversation among domain experts from the allied fields and develop a research agenda regarding analytics of learning in the context of humanities and design topics and developing interventions for different learner profiles while they explore aspects of layered understanding of narratives and design as their learning task.

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References


Development and Evaluation of a Computer Supported Collaborative Learning Tool for Teaching Activities Using Educational Board Games

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Abstract: Educational board games have been widely used in the teaching practice. However, when teachers use educational board games for collaborative learning in classrooms, they may have problems in monitoring students’ learning process. Students may also experience high cognitive load due to complicated rules and need immediate scaffolding guidance. This study developed a computer supported collaborative learning tool for board games (CSCLBG), aiming to help teachers apply board games in teaching. We also preliminarily evaluated this tool with empirical research. The results showed that learners’ learning effectiveness in the CSCLBG activities improved. Positive results were also found in learners’ flow and their technology acceptance. Moreover, learners showed lower anxiety in the activities.

Keywords: educational board game, CSCL, scaffolding, flow, anxiety

1. Introduction

Educational board games are useful tools to promote interpersonal interaction, encourage students’ learning motivation (LeBlanc & Bearison, 2014), and increase their flow experience and learning achievement (Hou & Lin, 2015; Li et al., 2017). Teachers can apply different scaffolds to support students’ learning by using educational board games. The board games may also provide peer scaffolding to promote peer interaction and learning achievement (Poole, Clarke-Midura, Sun, & Lam, 2019). Moreover, learners’ flow experience in educational game may affect their learning performances and behaviors (Hsieh, Lin, & Hou, 2016). Considering the game design that could increase student’s flow experience, Killi and Lainema (2008) suggested that the cognitive process was an important element which may influence flow experience. Cognitive load was an impact factor in cognitive process (Sweller, 2010).

Therefore, when using educational board games in classrooms, teachers need to increase learners’ flow experience, provide scaffolding, and reduce their cognitive load. On the other hand, using digital applications as the guiding tool may effectively assist teachers to conduct educational board game activities in the classroom. The combination of digital applications and educational board games could help reduce repetitive actions and mechanism quickly (Park, 2017).

Moreover, computer supported collaborative learning (CSCL) is a strategy that students constructed knowledge, interacted with group members, and solved learning task collaboratively with computer applications (Bayir, 2014; Cress, Stahl, Ludvigsen, & Law, 2015). A web-based application could guide the students to collaborate with peers, help teachers collect the students’ behavioral data immediately, and reduce the students’ cognitive load (Wu, Chen, & Wu, 2018).

When the teacher guided the students for group-based educational board game learning in the classroom, the teacher may face the following problems. For example, the teacher may be interrupted and asked to repeat the rules because the students forgot about them. The teacher may also have problems in monitoring the learning progress of each group and in analyzing students’ learning process.
For students, they may lack complementary information as the scaffolding in problem-solving activities. Moreover, students in collaborative learning groups may not be able to collaborate and complete game tasks due to complex rules and insufficient scaffolding.

Therefore, this study developed a tool to help teachers apply educational board games for CSCL teaching. This tool included many functions for teachers to solve various problems when implementing group-based CSCL educational board game activities in the classroom. For example, teachers could monitor the progress of real-time playing behaviors and the learning process of each group. The tool provided a step-by-step guide for the students to understand game rules, thus reducing their external cognitive load. The tool also provided cognitive scaffolding for the students when they played board games (e.g., supplementary learning resources and the real-time diagnosis).

The purposes of this study are as follows.

1. The study aims to develop a computer supported collaborative learning tool for educational board games, which could guide the students to play games and help the teacher monitor students’ learning immediately.
2. Teachers could apply functions of the proposed tool and a history educational board game in their teaching activities.
3. The study preliminarily evaluates students’ learning effectiveness, flow state, anxiety, and their acceptance of the tool in the learning activity.

2. Methods

2.1 Participants

Participant of this study included 48 undergraduate students from a college located in northern Taiwan, and they were 18-20 years old. All of them had information management background. They all attended the same history course for one year. In this study, participants needed to play a history educational board game which included the knowledge they had learned. They were also guided by the computer supported collaborative learning tool developed by the study.

2.2 Research Procedures and Tools

This study was a quasi-experimental design and only included a single group. The research procedures were as follows. First, participants were asked to do a pre-test about history knowledge. The contents of the pre-test were chronology of historical events in Taiwan, designed based on history textbooks. Second, the participants were divided into groups and asked to play a board game with the computer supported collaborative learning tool. Each group used one device and spent 30 minutes on game. Third, to the study explored the participants’ flow experience, anxiety, and technology acceptance. For example, the participants’ flow experience was measured with the flow scale developed by Kiili’s (2006) and translated by Hou and Chou (2012), and the scale was of high reliability (Cronbach’s α=0.967) and validity (KMO=0.832) for flow. The participants’ anxiety was measured with the questionnaire adapted by Krashen (Krashen, 1981; 1982), and the scale was of high reliability (Cronbach’s α=0.833) and validity (KMO=0.793) for anxiety. The participants’ technology acceptance was measured with our revised questionnaire of Davis (1989), including of the three dimensions of perceived usefulness, perceived ease of use, and game elements. The scale was of high reliability (Cronbach’s α=0.951) and validity (KMO=0.867) for technology acceptance. All these questionnaires used the five-point Likert scale. Fourth, the participants were asked to do the post-test about history knowledge. The questions in the pre-test and the post-test were identical in order to know whether the students acquired more knowledge after they played the game.

2.3 Educational Board Game: Voyage with Taiwan
Voyage of Taiwan is an educational board game for history learning (Lin & Hou, 2015) (Figure 1). This game included 89 event cards. On the front side of each card, the players could see a title of one historical event in Taiwan history, an example picture, and three keywords related to this event. On the back side of each card, the player could see the year period of the event and a brief description. Within limited time, the players needed to take as many cards as possible and read the information on the front side of the cards to decide the time sequence of events and get points. The students were assigned to groups for the activity and each group participated in the history learning activity with the help of Voyage with Taiwan and the CSCL tool developed by this research.

![Figure 1. Voyage of Taiwan](image)

2.4 The CSCL tool for educational board game

The proposed computer supported collaborative learning tool for board game (CSCLBG\textsubscript{beta}) provided multi-modules for teaching activities. Figure 2 shows the instructions of each module and the interface of CSCLBG\textsubscript{beta}. These functions were beneficial for players in educational board games. With the assistance from the system, the students could be guided step by step to play the game. Therefore, the students’ cognitive load could be reduced since the students did not have to memorize rules or calculate points by themselves. On the other hand, the teacher could provide complementary information as scaffolding for the students to help them solve problems in board game activities. The teacher could also monitor the students’ game progress from the data. Functions of each module are shown in Table 1. During the process of supporting Voyage of Taiwan, CSCLBG\textsubscript{beta} guided student the game progress, provided history information as scaffolding for the students, and helped countdown. During student playing game, CSCLBG\textsubscript{beta} send the data about duration of each actives, scores, and times of scaffolding using.
Table 1. The modules and functions of CSCLBG

<table>
<thead>
<tr>
<th>Module</th>
<th>Function</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The step-by-step guidance module</td>
<td>The players chose steps and they were guided step by step to complete the board game learning activities. The teacher could understand the learning progress of each group through this module.</td>
<td>The module provided guidance step by step and reduced players’ cognitive load. The students could better understand the gaming progress and focus on collaboration and communication on game tasks. The teacher could also immediately monitor the students’ learning process.</td>
</tr>
<tr>
<td>2. The group setting module</td>
<td>This module helped group setting and record learning information of each group.</td>
<td>The module assisted the teacher to monitor learning process.</td>
</tr>
<tr>
<td>3. The time setting module</td>
<td>This module helped set the countdown and set time limit for each step.</td>
<td>This module helped set time limit for each stage and assisted the teacher and group members to manage their time.</td>
</tr>
<tr>
<td>4. The task phase guidance module</td>
<td>The teacher could set game mission in each phase. The students could move based on the goal in each phase.</td>
<td>Since the mission and rules of each phase was given, the students did not need to memorize these rules and their external cognitive load was thus reduced.</td>
</tr>
<tr>
<td>5. The cognitive scaffolding module</td>
<td>The teacher could provide texts, pictures, and videos as the texts or images as scaffolding</td>
<td>The teacher could provide the texts or images as scaffolding.</td>
</tr>
</tbody>
</table>
complementary information. to assist students’ discussions and collaborative problem-solving tasks (e.g., problem-solving directions, multimedia clues, websites related to information for problem-solving tasks).

<table>
<thead>
<tr>
<th>6. The scoring module</th>
<th>The module provided students’ records and calculated their scores in the game.</th>
<th>This module helped reduce complex score calculations, thus lowering cognitive load.</th>
</tr>
</thead>
</table>

| 7. The game completion module | The module reported to the teacher that the game was completed, and the data would be sent to the cloud. | This module helped the teacher monitor students’ learning process and helped analyze their learning information. |

| 8. The game goal and rule module | The module showed the students completed rules and goals of the game. | This module reminded the students of the game goals so that they did not need to memorize the rules. The students could repeat reading the detailed rules and their external cognitive load could be reduced. |

3. Results

As for learning performance, Table 2 shows that the students’ learning performance improved after they had played the educational board game with CSCLBG (t=-4.703, p<0.001). This finding suggested that these students acquired history knowledge and had significantly better learning performance with the help of our educational board game and CSCLBG.

Table 2. The results of the paired sample t-test

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Mean</th>
<th>N</th>
<th>SD</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-test</td>
<td>32.81</td>
<td>48</td>
<td>27.95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-test</td>
<td>72.88</td>
<td>48</td>
<td>54.70</td>
<td>-4.703</td>
<td>.000*</td>
</tr>
</tbody>
</table>

As for the student’s experiences and their perceptions of the board game with CSCLBG, Table 3 shows the results of the flow scale, anxiety scale, and technology acceptance scale. As shown in Table 3, the means of the students’ overall flow (M=3.42) and acceptance (M=3.45) were above the median 3 in a five-point scale. The mean of the students’ anxiety was below 3 (M=2.54). Based on these findings, students in the CSCLBG and board game learning activities showed positive views on system acceptance (including perceived usefulness and perceived ease of use) and on flow. Moreover, they also showed low learning anxiety in the activities.

Table 3. Means and standard deviations of flow scale, anxiety scale, and technology acceptance scale.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td>3.42</td>
<td>0.76</td>
</tr>
<tr>
<td>Flow antecedents</td>
<td>3.49</td>
<td>0.76</td>
</tr>
<tr>
<td>Flow experience</td>
<td>3.37</td>
<td>0.81</td>
</tr>
<tr>
<td>Anxiety</td>
<td>2.54</td>
<td>0.63</td>
</tr>
</tbody>
</table>
4. Discussion and Conclusion

This study developed a tool that can be applied by teachers with educational board games in their group teaching. This tool had potential and could be applied into different fields. The study showed that learners’ learning performance improved after the CSCLBG activities. Moreover, positive results were also found in learners’ flow experience and technology acceptance. Learners did not show much anxiety in the game. These findings suggested that learners could apply this tool with the educational board game in learning activities. They concentrated on learning and they were deeply involved in learning without being affected by much anxiety. The prototype of this tool has been developed, and more modules would be added in the future. We will improve its visual interface and add teacher monitoring dashboard to make its functions more completed and promote its ease of use. Moreover, after this preliminary evaluation, future studies could include the experimental group (using CSCLBG only) and the control group (using board games only) for many other disciplines to analyze learners’ learning process and performance.

In addition, we suggest researchers explore learners’ cognitive load or learning behavioral patterns in the future (e.g., Hou, 2015; 2012). This helps us know whether learners could have better learning effectiveness and experience with the help of this tool.

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References


Development and Field Testing of a Narrative-Centered Digital Game for English Comprehension

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Abstract: This paper describes the development and field testing of Learning Likha: Rangers to the Rescue, a narrative-centered, mobile-based digital game for practicing English comprehension. Twenty-seven (27) student participants from Grades 4, 5, and 6 were invited to play the game and answer a comprehension test to determine their level of understanding of the game’s contents. Self-report questionnaires were also used to assess the extent to which they enjoyed playing the game. Three (3) teachers were likewise invited for a focus group discussion (FGD) to gather their insights about the game and how they may use it in their classes. Student’s self-reported feedback indicated they found the game fun, interesting, and sufficiently challenging. Post-test comprehension scores were generally good. Younger participants scored lower than their older peers but the differences were found to be not significant. Teachers indicated the game has the potential to be used as a supplement for their classes and that their students would enjoy playing it.

Keywords: game-based learning, English comprehension, Philippines, mobile-assisted language learning

1. Context and Motivation

The Philippines is a country in Southeast Asia with a population of 109 million, 51% of whom are under the age of 26 (CIA, 2020). A former US colony, English proficiency is one of the country’s strengths (Valderama, 2019 November 18). The availability of young, educated Filipinos with good spoken English has secured the Philippines’ place among the world’s top 10 business process outsourcing (BPO) destinations (Shead, 2017 April 17).

Unfortunately, results from recent international tests have suggested that the country may be losing its English proficiency edge. In an annual ranking of 100 countries’ English proficiency skills, the Philippines dropped from 14th in 2018 (Education First, 2018) to 20th in 2019 (Education First, 2019). The Programme for International Student Assessment (PISA) results published in of 2019 showed that the Philippines obtained an average of 340 points in Overall Reading Literacy and was classified at Proficiency Level 1a (Philippines Department of Education, 2019). By comparison, the average of the Organization for Economic Cooperation and Development (OECD) countries was 487, ranked at Proficiency Level 3, two levels higher than the Philippines’ country average. In the Test of English for International Communication (TOEIC) conducted by Hopkins International Partners, 10,000 Filipino test takers average 631 out of 990, equivalent to the intermediate or B1 level of the Common European Framework of Reference for Languages. This is the level expected from taxi drivers for the 2020 Tokyo Olympics.

Even within-country tests echo the same deficiencies. The Philippines Department of Education (DepEd) National Achievement Test (NAT) scores of Grade 6 students have been declining over the last three years (Albano Jr., 2019). The 2018 Grade 6 NAT results showed the national average Mean Percentage Score (MPS) to be at 37.44, the weakest performance in the history of the standardized
exam (Albano Jr., 2019). The DepEd Regional Office 02 (Cagayan Valley) reported that their 2018 NAT results for Grade 6 show that the mean performance by subject area were far below the 75% acceptable MPS with scores for English averaging 33.52% (DepED RO2, 2019).

These deficiencies are not uniformly distributed. Rather, their concentrations are determined by socio-economics. In the PISA, for example, Filipino students from private schools scored higher than those from public schools (390 vs. 328 respectively) (Philippines Department of Education, 2019). Urban students outperformed rural students (355 vs. 313, respectively). This implies that those most in need of economic opportunities are unable to participate in them because of a lack of language proficiency.

Several factors contribute to this situation. Schools are typically under-resourced, both in learning materials and teachers. Limited number of classrooms result to high student-to-teacher ratios (STR) which make teaching and learning difficult. In a PETS-QSDS (Public Expenditure Tracking Surveys-Quantitative Service Delivery Surveys) study conducted in 2014 involving a nationally representative sample of 946 Grade 10 high school teachers, approximately 38% mentioned the need for better physical facilities (Al-Samarrai, 2016). Additionally, about 60% expressed the need for additional teaching materials (Al-Samarrai, 2016).

As a response to this situation, the Ateneo Laboratory for the Learning Sciences has begun developing mobile phone-based games for English vocabulary learning and comprehension. In this paper, we describe the development and field testing of Learning Likha: Rangers to the Rescue (LLRR), a mobile game that exercises the skill of attention to details. The purpose of this paper is two-fold: (1) to describe how a narrative-centered digital game (NCDG) can be designed and implemented to teach attention to details and (2) to assess the target audience’s response to the game.

2. Mobile Learning

LLRR is implemented for use on mobile devices such as cell phones and tablets. Mobile learning has become popular in educational settings because the use of mobile devices allows learning to take place anytime and anywhere (Christensen & Knezek, 2017). The availability and diversity of mobile applications has expanded the affordance of mobile devices into providing access to learning beyond the classroom (Mouza & Barrett-Greenly, 2015). Designers of mobile learning applications exploit the ubiquity of mobile devices so they can be used in both formal and informal learning (Kukulska-Hulme, 2012) while resolving the location and time barriers inherent in traditional learning environments.

Mobile phones are regarded as the primary computing platform in developing countries. As of 2018, the developing world had an estimated 102.8 mobile phones for every 100 people (ITU, 2018). As such, teachers and students have turned to the use of these devices as a way to integrate technology in education. Additionally, research has shown that young learners tend to be receptive to mobile learning applications (Sung et al., 2016). Rodrigo et al. (2019) surveyed 710 Grades 4, 5, and 6 students from two elementary state schools in Quezon City, Metro Manila, Philippines to determine their level of access to technology. They have found that they have access to cellular phones (63%), computers (54%), and tablets (36%) (Rodrigo et al., 2019b). Since mobile phones emerged to be the easiest to access, the mobile platform seemed like a promising venue for providing support to a wider range of learners.

3. Digital Game-Based Learning

Games are playful activities that provide high motivational value (Park et al., 2019). Few instructional techniques are able to encourage similar levels of engagement on tasks as games do (Tobias et al., 2014). The increasing popularity of games used in teaching and learning can be attributed to the motivational affordances (e.g. immediate feedback, challenges) that are typically built into them (Anastasiadis et al., 2018). They provide enjoyable experiences that can stimulate learners’ motivation
while enabling the accomplishment of learning outcomes. Thus, educators are exploring the use of games for instruction because of their innate motivational qualities (Tobias et al., 2014).

Digital game-based learning (DGBL) pertains to the utilization of the entertainment power of games in educational contexts (All et al., 2016). It is characterized by a balance between teaching/learning and gaming (Prensky as cited in Beserra et al., 2014) to aid in the realization of learning goals. Games are commonly used to aid teachers in helping students acquire knowledge and skills in a variety of topics such as science, mathematics, and language learning, among others (Abdul Jabbar & Felicia, 2015). Moreover, DGBL is considered to be an instrument that is in a good position to promote 21st century skills such as creativity (Hsiao et al, 2014) and problem-solving (Lester et al, 2014)

3.1 Narrative-Centered Digital Games

Learning Likha: Rangers to the Rescue is an implementation of a DGBL format known as Narrative-Centered Digital Games (NCDG). NCDGs situate educational content and problem-solving activities within interactive story scenarios (Rowe et al., 2010). Story features such as believable characters and immersive plots are integrated into DGBL environments to help motivate learners and encourage them to persist in learning tasks for longer periods of time (Rowe et al., 2012). According to the Narrative-Centered Learning Theory, there are two (2) ways in which narrative can help motivate learners: (1) learners, through text, are transported to a different time and place that is real to them; and (2) learners themselves perform the narrative. Much of the appeal of NCDGs arise from their ability to contextualize educational content with interactive stories (Lester et al., 2013). Additionally, they have a natural capacity to foster engagement by tightly integrating learning goals into rich narratives.

3.2 Mobile-Assisted Language Learning (MALL)

Mobile-Assisted Language Learning (MALL) is an area within mobile learning that focuses on various language learning areas such as grammar, listening and reading comprehension, and vocabulary acquisition (Miangah & Nezarat, 2012; AbuSa'a'aleek, 2014; Sung et al., 2015). Language learning is said to be effective if the learner is exposed to the target language in meaningful contexts even outside of the classroom premises (Eun & Lim, 2009; Peterson, 2010; Amer, 2014). An example is a work by Yin et al. (2010) which explored the use of MALL to teach Japanese Polite Expressions (JPE) to support foreigners through a context-aware language learning environment. Additionally, there are studies that explore the use of story/narrative-based games for teaching languages such as English (Chen et al., 2018) and Spanish (Prestopnik, 2016). Affordances of real-world experiences for learning a targeted language such as communicative and interactive activities were designed into the virtual environments to give learners the opportunity to learn the language within a narrative context.

4. Learning Likha: Rangers to the Rescue

LLRR is an NCDG that helps learners exercise their English reading and listening comprehension skills, and to practice the skill of noting explicit details. As a secondary objective, it exposes the learners to a variety of endangered species in the Philippines.

LLRR is the successor of a game Learning Likha: Music for the Fiesta (Rodrigo et al., 2019a). In Learning Likha: Music for the Fiesta, the player helps the main character, Likha, collect instruments that her band needs in order for them to play during the town’s feast day. To achieve her mission, Likha needs the details regarding the instruments and their locations from her fellow band members and various shop keepers. A full description of this game and its field test results are available from Rodrigo et al., 2019a.

LLRR follows the same structure. The game’s setting and initial motivation are first established through the use of a narrative: Likha, her friend Taro the Tarsier, and four other volunteer rangers help rescue animals and bring them to the Rescue Center in their town, Hiraya. Each volunteer is assigned
to rescue or help one of the following endangered species: a freshwater crocodile, a hawksbill turtle, a tamaraw, a warty pig, and a Philippine eagle. The game starts with Likha and Taro welcoming the player as the new volunteer ranger to Hiraya’s Rescue Center. The player is then invited to the Rescue Center’s Holding Area in which he/she selects one of the volunteer rangers (Figure 1).

A spoken and written dialogue between Likha, Taro, and the selected ranger describes the endangered animal to be rescued/treated and/or a related task that needs to be completed (Figure 2). Images and text on the game screen containing descriptive details supplement the audio that plays. There is also a notepad on the upper right corner of the screen that lists the key details about the animal to be rescued or the task to be completed. Given this information, the player needs to find the correct animal in the scene or perform the task based on the description provided by the dialogue. Feedback is given whether the player’s choice is correct or wrong. A short explanation about the animal is also given after (Figure 3). The player does this for all volunteer rangers until all animals have been rescued. LLRR is available free of charge from both the Google Play Store and the Apple App Store.

Figure 1. Hiraya’s Rescue Center’s Holding Area where player selects one of the rangers.

Figure 2. Sample dialogue scene describing the task after a ranger has been selected.
5. Testing Methods

The testing was conducted at a public school in Quezon City, Metro Manila, Philippines. Teachers of Grades 4, 5, and 6 were asked to randomly select students from each grade level that may be invited to participate. During the study, the participants were grouped by grade level. Each grade level had separated testing sessions due to the limited number of cellular phones and earphones. Once settled in the venue, they were oriented on the objectives of the study and the details of their participation. They were then asked to complete a demographics questionnaire to determine their level of access to mobile phones. Additionally, it tried to determine their usage, attitude, and perceptions towards the English language by giving them 8 statements to which they would indicate their level of agreement (1 = Strongly Disagree to 5 = Strongly Agree). Sample statements are:

- I speak English at home.
- I find English difficult to learn.
- Learning English is important.

Once the participants completed answering the demographics questionnaires, mobile phones were handed to them. They were then asked to play LLRR for 20 minutes. They were also provided with earphones that they used while playing for full auditory attention.

After completing the game, or when the 20-minute allotted play time had passed, a post-test comprised of 19 multiple choice questions and 4 open-ended questions was administered to measure how much they remembered and understood the details from the story. Sample questions are:

- What is Taro?
  a. Monkey     b. Dog       c. Cat       d. Tarsier
- What was the story about?

The participants were also asked to complete one final questionnaire with two sections, adapted from the Game-Based Learning (GBL) Engagement Metric (Chew, 2017) and the Intrinsic Motivation Inventory (IMI) (Ryan, 1982). The goal of the GBL questionnaire was to determine how engaged the students were with the game by asking them for their levels of agreement to 8 statements such as “I followed the instructions carefully in the Learning Likha: Rangers to the Rescue game.” On the other hand, the IMI questionnaire posed 9 questions that asked participants to indicate if the statements were not at all true (1), somewhat true (4), or very true (7). A sample statement is “I enjoyed playing Learning Likha: Rangers to the Rescue very much.”

Three (3) English teachers were likewise invited for a focus group discussion (FGD) to gather their insights about the game and how they may use it in their classes. They were asked about what they liked and did not like about Learning Likha: Rangers to the Rescue. Suggestions for improving the game were also solicited from them.
6. Analysis

6.1 Participant Profile

A total of 27 students participated in the study: 10 from Grade 4, 7 from Grade 5, and 10 from Grade 6. Out of the 27, 13 were male and 14 were female (Table 1). Majority of the students owned cell phones. Most of them played cell phone games, some of which were educational.

Table 1. Profile of Participants

<table>
<thead>
<tr>
<th>Grade 4</th>
<th>Grade 5</th>
<th>Grade 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>M</td>
<td>F</td>
</tr>
<tr>
<td>N</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Age Range</td>
<td>9 - 12</td>
<td>10 - 11</td>
</tr>
<tr>
<td>Had their own cell phones</td>
<td>5 (50%)</td>
<td>5 (71%)</td>
</tr>
<tr>
<td>Played games on cell phones</td>
<td>8 (80%)</td>
<td>5 (71%)</td>
</tr>
<tr>
<td>Played educational games on cell phones</td>
<td>7 (70%)</td>
<td>5 (71%)</td>
</tr>
</tbody>
</table>

When asked about their usage, attitudes, and perception towards the English language, students were impartial about whether they spoke English at home (3.0/5.0) or with their friends (3.1/5.0). They did enjoy learning (4.3/5.0) and reading (4.3/5.0) in English. They expressed a desire to learn English (4.5/5.0) and agreed that it is important (4.5/5.0). These show that though the participants may not typically use English as a medium for communication, they do recognize its value and enjoy learning it.

6.2 Game Engagement and Comprehension Scores

The students generally self-reported positive feelings and attitudes towards the game. Results of the GBL questionnaire show that they carefully followed the instructions (4.6/5.0) and tried their best to pay attention to the details of the story (4.6/5.0). They were able to use their prior knowledge (4.5/5.0) and they agree that what they were learning from the game were important (4.7/5.0). They said playing the game interested them (4.6/5.0), that they fondly anticipate completing the tasks (4.7/5.0), and that the game was somewhat challenging (3.9/5.0).

The IMI results were similar. They expressed enjoyment (6.8/7.0), was interested (6.7/7.0), and said it was fun to play (6.9/7.0). It was important that they did well in the game (6.7/7.0), and so they tried their best to successfully perform the game tasks (6.7/7.0).

The results of the comprehension post-test were also generally good. Grade 4 students’ post-test scores averaged 65%, Grade 5 students averaged 75%, and the Grade 6 students averaged 76%. A single-factor ANOVA showed that the differences between groups were not significant (F(2,24)=1.27, p=0.3). These results demonstrate the game’s potential to foster positive emotions and contribute to the realization of learning outcomes.

6.3 Focus Group Discussion (FGD) with Teachers

A focus group discussion (FGD) was conducted with three (3) teachers (one representative per grade level) to learn more about the types of activities they give their students that are focused on reading comprehension and noting specific details. The FGD also sought to gather their insights regarding LLRR.

4.1.1 Classroom Activities for Identifying Details and Reading Comprehension

Seat works/homeworks on identifying details typically come in the form of giving learners stories to read and asking them to do one of the following: (1) enumerating specific story details; (2) listing down
their questions about the story; or (3) creating an outline of the story. Students are also asked to engage in silent and oral reading to improve their reading comprehension skills. According to the teachers, encouraging students to read in groups and present their learning might be a potential approach for improving their skills in identifying details. They asserted that students like to work in groups because they have someone to discuss with. Providing a reading corner that they can use during free time could encourage students to read more. Additionally, students are drawn to colorful, animated materials delivered through more modern-day medium such as laptops and cell phones.

4.1.2 Teachers’ Insights Regarding LLRR

Based on the teachers’ comments, they liked how LLRR teaches the students about the various endangered species in the Philippines and how they can be saved in certain situations. They were delighted by the rangers’ names as they were “very Filipino”. When asked about what they least liked about the game, they said some of the items were quite difficult to find, such as the plastic bottles and the Philippine Eagle. The teachers see the potential of LLRR being used in the classroom. They said they can use the game as a springboard to their lessons, acting as a tool for motivating the students. They think it would be a good supplement for teaching nouns and following directions. They also said that it can be integrated in other subjects such as Science and Values. Overall, they think the students would enjoy the game in their classes.

7. Conclusion

In this paper, we discuss the implementation and testing of Learning Likha: Rangers to the Rescue, a narrative-centered digital mobile phone game to help with practicing English comprehension and attention to details. The student participants found it interesting and fun. They exerted effort in understanding the content and completing the game tasks. Their comprehension scores were generally good in spite of them being non-native English speakers. The younger participants’ scores were lower than their older peers but the differences were found to be not significant. Generally, the students expressed interest in learning English and understand the value of developing their reading comprehension skills.

A limitation of the study is that there was no baseline assessment of the participants’ pre-existing English language skills. Hence, assessment of learning gains is not possible at this time. Still, this work is an attempt to address the need for additional learning materials that can be used in the classroom. The conversation with the teachers shows there is potential in utilizing the game in their classes. They have identified certain topics in their curriculum that could benefit from incorporating LLRR as a supplementary material. They think it could help in motivating students by making learning fun and interesting. Additionally, the game’s narrative was particularly designed for Filipino learners to make it more relatable and familiar to their context. As previously mentioned, the mobile platform is the most accessible to a wider range of audience, including those who may be underprivileged. The hope is that this game, as well as its predecessor, Learning Likha: Music for the Fiesta, is in some way able to supplement the realization of learning goals.

Acknowledgements

We thank the Ateneo de Manila University; the principals, teachers, volunteers, and learners of our partner public schools for their participation; Ma. Rosario Madjos; and the Commission on Higher Education and the British Council for the grant entitled JOLLY: Jokes Online to improve Literacy and Learning digital skills amongst Young people from disadvantaged backgrounds.
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Development of a mobile ten frames app for Philippine K-12 schools

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Abstract: This paper reports on the Quick Images app, whose design framework is informed by research on ten-structured thinking and gamification principles. Inclusivity was also a major consideration, especially in the context of a developing country. Thus, the app was made freely available and required only moderate system requirements. Pilot studies revealed that the app has the potential to promote children’s ability to see two-digit numbers in relation to tens and ones, which is a major goal of elementary school mathematics. Collaborations with the Philippine Department of Education to ensure the app’s sustained use are also discussed.

Keywords: Mobile math apps, mobile technology, ten frames

1. Introduction

Current mathematical education research emphasizes the importance of critical thinking and problem solving, and these form the twin goals of Philippine mathematics education (Department of Education [DepEd], 2016). However, Filipino children in the elementary grades often gain only a superficial understanding of mathematics (Verzosa, 2015a). Mathematics is learned by memorizing rules or procedures, with little understanding of number sense, which is a prerequisite for learning more advanced mathematical concepts (Siegler & Lortie-Forgues, 2014). Additionally, elementary school teachers even with training in elementary mathematics, may not be able to immediately translate such training to the classroom (Verzosa, 2015b). A team of mathematicians and mathematics educators with the support of the Philippine Department of Science and Technology - Philippine Council for Industry, Energy and Emerging Technology Research and Development (DOST-PCIEERD), came together to create mathematical mobile applications (apps) for Grades 1 to 6 Mathematics to address the aforementioned issues and concerns (De Las Peñas et al., 2020).

The apps integrate current mathematics education research in its design. These tools were based on what had been learned from cross-national large-scale research projects (Bobis et al., 2005). Further, the representations in the app were digital versions of concrete materials that had already been pilot-tested in classrooms, using traditional (paper) materials (Verzosa, 2015a, 2020). In this intervention, elementary school pupils who were exposed to number sense ideas over 8-10 two-hour informal sessions posted gains in place value knowledge. It is anticipated that a more frequent and sustained exposure to number sense ideas using these digital tools would lead to larger gains.

In addition to the aforementioned solid pedagogical and empirical basis, the apps were designed to be easy-to-use and easy-to-play; and are engaging and interactive. Thus, the apps can be used even with minimal supervision, and are very apt for student-centered or remote learning. Moreover, through constant play and exposure to the apps, students’ understanding of mathematical concepts is enforced. By playing the game, children develop a better understanding of the math principles involved. To make the apps accessible to public and private school children and teachers all over the country, the apps were made free and were created to run on mobile technology with moderate system requirements.

This paper presents a focused look on the development of Quick Images. This app aims to promote mastery of addition and subtraction facts, which is an official learning outcome in the early elementary grades. Moreover, even Grades 5 or 6 children who have poor number sense may also benefit from the visual representations offered by the app (Young-Loveridge, 2002). Its design was
informed by a framework based on ten-structured thinking, which is an essential conceptual advancement in the elementary grades (Fuson, Smith, & Lo Cicero, 1997).

2. Ten-structured Thinking

Ten-structured thinking, or the ability to think of 2-digit numbers in terms of tens and ones, is one of the major objectives in elementary mathematics (Fuson, Smith, & Lo Cicero, 1997). It is a “big idea” because it is connected to and is a foundation for many other mathematical concepts, and provides an organizational structure (Siemon, Blecky, & Neal, 2012). Unfortunately, many children continue to rely on counting by ones even in the upper elementary grades (Verzosa, 2015a; Young-Loveridge, 2002).

A child may conceptualize a number, say four, as a set of dots (Figure 1a), but this conception does not elucidate a number’s relationship to five or ten. A stronger conceptualization occurs when a number is anchored on five or ten, and this is naturally demonstrated by five-frame and ten-frame manipulatives (Figure 1b and 1c). Here, it becomes clearer that four is one less than five (Figure 1b) or that four and six make ten (Figure 1c). In a study by Young-Loveridge and Bicknell involving children of ages five to seven, it is reported that the use of five- or ten-frame structures help in identifying groups of ten (Young-Loveridge & Bicknell, 2016). Indeed, these aids have been recommended as effective visual materials for promoting ten-structured thinking among young children (McGuire, Kinzie, & Berch, 2011; Murata & Stewart, 2017), supplement intervention for upper elementary grade children who had not mastered the basic addition and subtraction facts. These manipulatives were the primary instructional material utilized by the app described in this paper.

![Figure 1. A sample arrangement presented (a) randomly, or through a (b) five-frame or (c) ten-frame manipulative](image)

3. The Quick Images App

A teaching strategy that can maximize the potential of the five-frame and ten-frame framework is called “quick images” (Clements, 1999). A picture of five frames or ten frames is shown quickly, while children call out the number shown. Because the images are flashed quickly, children are trained to naturally develop counting by tens (or groups) instead of by ones. Some apps that display ten frames already exist. However, in most of these apps, the ten frames remain shown on the screen and children can count the dots one by one, so the development of more sophisticated strategies is not promoted. There is one GeoGebra app (Ulbright, n. d.) where ten frame patterns are flashed on the screen. Quick Images improves on this app by flashing ten frames and other dot patterns through a sequence of tiered difficulty levels that develop addition and subtraction strategies.

3.1 Pedagogical Design

Broadly, Quick Images presents some dots on the screen (Figure 2). The dots disappear after 0.5s, 1.5s, or 2.5s, depending on the speed option chosen by the user. The goal is to determine the number of dots shown, and to answer as many tasks as possible within 30 seconds. Quick Images offers 66 levels or challenges whose sequence is determined pedagogically. In the most basic levels, pictures of objects are shown (Figure 2a). Next, five frames with pictures of objects are presented (Figure 2b), followed by the more abstract five-frame (Figure 2c). The next set of challenges includes ten frames (Figure 2d), double ten frames (Figure 2e) and numerals (Figure 2f).
Aside from the increasing complexity of the visual representations, the sequence of questions follows a developmental approach as well, with each level focusing on a specific strategy. For example, one challenge focuses only on doubles patterns (Figure 3a). The goal is to help children master the doubles facts so that they can apply this knowledge to answer near-doubles facts (Figure 3b). Thus, Quick Images is intended to facilitate a strategy for answering a near-doubles fact such as $6 + 7$ by applying a doubles fact: $(6 + 6) + 1$ (Van de Walle, Karp, & Bay-Williams, 2015). The general goal is to prompt students to develop thinking strategies especially because mathematics education in the Philippines is often characterized by imitative or superficially learned strategies (Van den Berg, 2009).

![Figure 2. Increasing abstraction in ten-frame tasks.](image)

![Figure 3. Doubles and near-doubles strategies developed by Quick Images.](image)

### 3.2 Gamification Features

Playing video games remains to be a popular entertainment activity, especially among the youth. In the Philippines, it is estimated that there are around 40 million gamers, 75% of whom play games on a mobile device (Elliot, 2020). Coupled with the sudden shift to online or distance learning due to the COVID-19 pandemic, it is valuable to use the widespread popularity of gaming to enrich the learning experiences, especially asynchronous ones, of students.

Quick Images had been designed to gamify the experience of learning through the five-frame or ten-frame framework. Moreover, as previously mentioned, the potential of this framework is maximized by adapting the strategy of “quick images.” To develop an effective and successful educational game, it is important to balance the input of educators or pedagogy experts and the input of game designers (Hirumi & Stapleton, 2008). To ensure this, the development of Quick Images involved detailed and comprehensive discussions of a team composed of educators and game developers.

Moreover, the development of Quick Images adheres to the Educational Games Design Model proposed by Ibrahim and Jaafar (2009). This model consists of three factors: Game Design, Pedagogy, and Learning Content Modelling. Table 1 shows how Quick Images, which was based on ten-structured thinking (Fuson et al., 1997) and a strategy proposed by Clements’ (1999), also adheres to Ibrahim and Jaafar’s (2009) gamification model.

On the factor of pedagogy, the previous section details how Quick Images addresses the learning outcomes pertaining to ten-structured thinking. In addition, it features a scoring system which
presents a natural motivation for the user who may want to improve one’s own top score and/or who may initiate a friendly competition with his/her peers. Moreover, *Quick images* is ideal for independent use and student-centered learning since its mechanics are clear and straightforward. When advancing to more difficult levels, for example, the user performs problem-solving rudiments to develop more efficient strategies to determine the number of dots flashed on the screen.

### Table 1. *Game Design of Quick Images*

<table>
<thead>
<tr>
<th>Element</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usability</td>
<td>The color theme, font types and sizes, object designs and sizes are catered to its target audience (i.e., grade school students). The app features different modes and difficulty levels for more diverse experiences.</td>
</tr>
<tr>
<td>Efficiency</td>
<td>Through the use of quick images and strategically designed and tiered difficulty levels, the app allows the users to naturally develop and master counting and arithmetic techniques.</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>The app is designed based on the five-frame and ten-frame framework; and gamifies the use of quick images to maximize the potential of the framework.</td>
</tr>
<tr>
<td>Multimodal</td>
<td>The app uses a combination of texts, figures, designed objects, and sound prompts.</td>
</tr>
<tr>
<td>Interaction</td>
<td>The app features an interactive game that mainly takes user input through button presses. There are sound prompts for correct and incorrect answers.</td>
</tr>
<tr>
<td>Fun</td>
<td>The challenge lies in achieving the highest score possible within the given time limit. There are different levels of abstraction, different speeds (slow, medium, fast), and different levels that allow for customization of the difficulty level.</td>
</tr>
<tr>
<td>Clear goals</td>
<td>The goal is simple and clear: to count the number of dots flashed on the screen and to maximize the number of correct answers within the given time limit.</td>
</tr>
<tr>
<td>Uncertain outcome</td>
<td>The number of dots flashed on the screen is random but strategically planned, depending on the level. The user’s score within the time limit is dependent on his/her skill level.</td>
</tr>
<tr>
<td>Self-esteem</td>
<td>The user’s self-esteem is developed as s/he progresses through the tiered difficulty levels and the different modes/speeds.</td>
</tr>
</tbody>
</table>

Finally, on the aspect of learning content modelling, *Quick Images* was designed so that it is aligned with the most essential learning competencies for Grade 1 (DepEd, 2020) set by DepEd in their Curriculum Guide. These competencies include: i) visualization, representation, counting of numbers 0 to 100 using a variety of materials and methods; ii) identification of the number that is one more or one less from a given number; iii) regrouping of sets of ones into sets of tens and sets of tens into hundreds using objects; iv) visualization and addition of two one-digit numbers with sums up to 18 and three one-digit numbers; v) visualization, representation and subtraction of one-digit numbers with minuends through 18 (basic facts), one to two-digit numbers with minuends up to 99 with and without regrouping; and vi) subtracts mentally one-digit numbers from two-digit minuends without regrouping using appropriate strategies. *Quick Images* also serves as a review tool to facilitate the learning of competencies of higher grades (Grades 2-6).

### 4. Integration of Quick Images into an online or blended classroom

Since *Quick Images* is mapped to specific learning competencies, its integration in the classroom, a learning management system, or a blended learning environment can be conceivably achieved. Its
design and functionalities allow it to be utilized as a practice tool to enrich a student’s ten-structured thinking, or as an assessment tool to gauge the student’s level of development in the said skill.

Several Grades 1 to 6 teachers prepared video lectures on number identification. These videos were posted in a School Division’s portal and may be used by other teachers in their online classrooms. Shown in Figure 4 are screenshots of a 5-min video lecture (Mathematics Teachers Association of Mandaluyong, 2020) of a Grade 1 teacher demonstrating *Quick Images* as a complementary activity to a lesson on number identification. In the first half of the video (Figure 4a), the teacher reviewed the counting numbers from 1 to 10 through pictures of familiar objects. Using different sets of static images, the teacher guided the students in identifying the number of objects shown.

The second half of the video shows the teacher using *Quick Images* to practice or enrich the students’ quick number identification skills (Figure 4b). The teacher introduced *Quick Images*, explained its interface, how it is played, and its important features and options. The simplicity of *Quick Images*’ design allowed the teacher to discuss its features in less than 30 seconds. This is important since the attention of the students must be focused on the practice activity provided by the app rather than on the app itself. Afterwards, the teacher engaged the students to play *Quick Images* with her. Occasionally, she clicked on the “show again” button to redisplay the objects in case some children might need to see the objects again. Towards the end of the video, the teacher encouraged the students to independently play with the app and send her a screenshot of the page which displays their score.

Teachers who created the videos and integrated *Quick Images* into their lessons answered some feedback/evaluation forms. They found the app easy to use and integrate in lessons. Some commented that *Quick Images* is very helpful and adaptable into a blended learning setting because it offered a strategy to make mathematics interesting and accessible when the teacher is not always present as in a physical classroom setting. Moreover, one teacher commented that the “advantage [of] *Quick Images* is [that it is] interactive and the students can play it over and over again while at the same time learning the mathematical concepts, which will be difficult to achieve in static worksheets.” Pilot studies with 6- to 9-year-old children also demonstrated that the app was enjoyable to use. Even after just one session with the app, some children learned new strategies, such as determining the number of dots by looking at the number of empty boxes.

5. Conclusion and Future Direction

This paper gives a detailed look into one of the mathematical mobile applications designed and created for the teaching and learning of mathematics in Grade 1 to 6, the *Quick Images* app. It discusses its gamification features as well as the theoretical framework and the mathematical pedagogies that form the basis of its creation. *Quick Images* showcases how mathematical activities in the traditional classroom setting can be transformed and framed in a gamified environment through a mobile app for elementary mathematics. The gamified version also offers a feature that is not possible when using concrete materials—in the app, the dots disappear after a fixed amount of time, which discourages learners to count by ones. Additionally, elementary school teachers who may not be able to apply the knowledge gained in in-service trainings (Verzosa, 2015b), can readily apply the new teaching strategy integrated within the app. *Quick Images* is currently being integrated by teachers into the lessons for
Grades 1 to 6 Mathematics in blended learning for the school year 2020-2021. While Quick Images shows much potential in mathematical learning evidenced by the positive feedback from teachers and the learners who have used it, the next few months will entail the study of its efficiency in improving the performance of selected classes in public schools through learning-related questionnaires and microgenetic interviews.

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Playful Learning and shared Computational Thinking: the PaCoMa case study.

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Abstract: We know from previous studies that tangible kits support lively and playful forms of shared sense-making better than digital, computer-based solutions. A typical problem that we observed, when groups of learners work on a shared activity at a computer, is a tendency to work one at the time, often leaving less expert or less active learners at the margins. However, we observed that tangible materials such as paper or fabrics, afford more naturally face-to-face engagement in small groups, allowing for eye-contact, dialogue and active engagement. In this paper we focus on playful learning activities about Computational Thinking, for early primary school pupils, and aim to better define the requirements for a new kind of tangible learning materials that we call PaCoMa, short for Paper Computing Machines. Our research questions deal with the role of tangible play in CT learning, and tangible play in shared sense-making. This paper describes our theoretical and design-based explorations of how to design an activity popup book to introduce kids 6 to 11 years old to CT. At a practical level, we discuss how paper-based mechanisms can represent the state of a variable or a machine, how to generate random symbols, how to embed code-like rules about jumping from state to state, as well as how to represent sequences of instructions/choices as physical objects. Armed with these mechanisms, we discuss the design of exemplar paper machines and propose scenarios of use in shared CT learning activities. Our scenarios address the emergence of shared affinity spaces, which we consider a precondition for simulative play, and to provide room for negotiation and creation of meaning through the paper machines. To assess the potential benefits of this tangible, analogue approach, qualitative tests are being organized with local and international institutions.

Keywords: Computational Thinking, primary school, playful learning, tangibles, analogue computation

1. Introduction

In the past 15 years we have been working on what is now called Computational Thinking (CT for short), and we have gained significant experience in collaborating and supporting playful learning activities in primary schools and non-scholastic institutions in Denmark (Valente, 2004, Marchetti & Valente, 2015, Valente & Marchetti, 2017, Valente & Marchetti, 2019, and Pedersen et al., 2020). Our interest focuses on the intersection between playful learning (PL for short) and CT, and we investigated both technological solutions (such as Valente & Marchetti, 2019, and Pedersen et al., 2020) and analogue, tangible kits and approaches for playful and active learning, like in Valente & Marchetti (2017).

During our previous studies, we noticed that tangible kits seem to support more lively and playful forms of shared sense-making than digital solutions, especially those used on a regular computer. When working on a computer on shared face-to-face activities, learners tend to work one at a time: often one codes while the others watch. As a result, the most proficient learners are also the most active, while those in need of more practice remain less active, hence not overcoming their difficulties. On the other hand, we observed that tangible materials (such as paper or fabrics) afford more naturally face-to-face engagement in small groups, allowing for eye-contact, dialogue and active engagement (Pedersen et al., 2020).
In this paper, we want to take a closer look at play in the context of playful learning activities aimed at CT, to better define the requirements for a new kind of tangible learning materials that we call PaCoMa, short for Paper Computing Machines. In this respect, our research questions deal with:

- The role of tangible play in CT learning,
- Tangible play in shared sense-making

This paper describes our theoretical and design-based explorations of the affordances of how to design an activity popup book to introduce kids 6 to 11 years old to CT: the idea is to address these pupils, which are in the concrete operational stage according to Piaget (as also discussed in Bers, 2020), and engage them with a series of DIY, hands-on tinkering exercises, using popup tangibles to play and learn about CT, alone or in small groups.

The rest of the paper presents our reflections and findings about playfulness, game-based learning and the challenges of adopting them within CT (section 2). The design process behind the PaCoMa activity popup book is presented in section 3, together with a discussion of scenarios of use. Section 5 concludes the paper and presents ongoing and future work.

2. Playful learning for CT

PL is defined as an experience harmoniously combining play and learning, in which players acquire new knowledge through play. Play is itself a free, ambiguous experience, centered on the players’ goals and defying clear definitions. However, play is defined as a transformative practice, through which players create their own world through their actions, transcending their present circumstances as if they were hallucinating (Gee, 2017, Vygotsky, 1978). In PL players act as if they were simulating themselves the situation depicted in the game, imagining themselves inside the game, leading them to reproduce specific aspects from the targeted knowledge domain (Gee, 2017). Hence, the players engage in problem solving, requiring application and in-depth reflections of the targeted knowledge (Vygotsky, 1978, Gee, 2017).

In order to foster such experience in PL, play shifts from a free to a regulated practice, framed within the constrained systems of rules of the adopted game (digital or analogue), yet still aiming at eliciting fun and a feeling of gratification (Bogost, 2016). Differently from free play, games are centered around a challenge, through which players experience “game breakdowns” (Benton et al., 2019), conceptual or systemic contradictions to be solved. Breakdowns can be generated by players’ unsuccessful actions in the game, due to lack of understanding on what to do next or lack of involvement, due to boredom or frustration (Benton et al., 2019). Facing such breakdowns, players are forced to develop strategies to achieve “game breakthroughs” (Benton et al., 2019), which are players’ achievements in problem solving, through the use of acquired knowledge.

In this way, as players learn how to play a game, they are learning the knowledge and skills targeted by the PL activity they are attending. Players are facilitated in their learning process by instructional design, narrative, rules, and mechanics embodied in the game challenges. Rules and mechanics provide a constraining framework, forcing the players to acquire the targeted knowledge and skills to win the game, while hindering them from finding shortcuts. In this sense, game rules and mechanics act as resources for pedagogical alignment (Biggs and Tang, 2011), as by winning the game the players are supposed to fulfill the goals of the game as well as the learning goals.

Interestingly typical PL applications for CT, such as MIT Scratch, Google Blockly or BBC Micro:bit, are aimed at a single player/learner, more or less explicitly. This might also be a consequence of the fact that such applications are developed to be used on computers and laptops, which do not easily enable more than one individual at a time actively using the system. Through previous studies, we noticed that when a group of learners is given a task to complete on the computer, only one learner actively engages with the system, while the others sit around and participate in a more passive way. Typically the active learner is also the one who is more proficient than the others in solving the given task, acquiring a leading role, hence the one who has less need to learn is the most active, while those who would need more practice, end up acting in more passive roles. On the other hand, PL is supposed to benefit from the social dimension of play, acknowledging that social play contributes to the
emergence of shared forms of meaning making. Through social play, players inspire each other, engage in competition or collaboration, creating affinity spaces (Gee, 2017), imaginary worlds delimited by the participants’ presence, actions, and physical or virtual context of interaction. We find that in PL these affinity spaces provide room for creation and negotiation of meaning, in which the players can inspire each other in embracing new ideas or possibilities for winning their game, also supporting each other when facing game breakdowns or simply issues when lacking understanding of the game or of the digital system available. We have previously found (Pedersen et al., 2020) for instance that design thinking activities and interaction with tangible, analogue materials like fabrics to make interactive puppets, better support social sense-making than simply working individually on the computer. Based on such insights, we aim at exploring forms of analogue CT, supported by shared forms of tangible interaction and design thinking.

In fact, one of the goals of CT is to introduce learners to a computational way of thinking and solving problems (Wing, 2006). Interestingly, when we consider professional programmers (e.g. game developers) we notice that their development methodologies usually involve plenty of low-fidelity prototyping, typically with paper or simple materials like LEGO bricks or modeling clay. In this paper, we advocate to leverage on such techniques also for pupils, which in our experience with Danish educational institutions are already used to tinkering as part of their learning. Since we want to scale down CT and turn it into a playful activity, suitable for young pupils, we looked at Paper’s constructivism and attempted at demystifying computation by showing how to remake computing machines as tangible, manually operated devices. This scaling down also requires avoiding or at least seriously reducing the dependency of CT on math; in this paper we propose to soften the math requirements of CT by looking at computation as manipulation of symbols, instead of a way to perform calculations.

We have conducted a preliminary survey of activity books for 6 to 10 years old, and we found many examples, such as McManus & Magar (2017), a successful book translated in multiple languages in Europe; however, these materials are intended for play and work at home, typically not adopted by institutions, and have very simplistic and superficial CT contents. Interestingly many of the books we surveyed suggest continuing the paper-based activities as Scratch projects.

Finally, we see our idea of designing paper computing machines as a way to implement tangible and playful notional machines. A notional machine is “[...] an abstraction designed to provide a model to aid in understanding of a particular language construct or program execution. The notional machine [...] presents a higher conceptual level by providing a metaphorical layer above the real machine [...] that are hoped to be easier to comprehend than the real machine.” (Berry & Kölling, 2014). Interestingly, a notional machine can be defined in many different ways, from a visual representation implemented as software, to a simple set of rules and tangibles operated by learners (like the tabletop games about CT analyzed in Scirea & Valente, 2020). Looking at board games to support playful learning of complex phenomena and systems is not a new idea (see for instance in the inspiring approach in Lin & Hou, 2016); however, here we propose to adopt a similar approach for CT and for young pupils, which presents specific problems, as discussed in the next section.

3. Design of PaCoMa’s activity popup book

The PaCoMa activity book should work similarly to print-and-play games (Ferdinands, 2019), that can be printed, eventually customized, cut and folded, to become tabletop games for one or more players. In the case of PaCoMa, the pupils and their teachers will print and play, i.e. they will build computing machines with paper, then play with them in groups, to solve a possible computational problem, and reflect on how computation works. As they get more proficient with these machines, the learners should also be able to modify them, customize them, to solve other, related problems; and finally they will be able to design new computing machines to work with new, possibly more complex problems. To achieve this, we need to look at which topics within CT we can cover with the activities in the book, then which paper mechanisms can we propose to our target group, for their tangible play and paper-and-scissors activities.
We have been working on a structure for the PaCoMa activity book that focuses on playing with computation and communication, abstracting from programming languages and hardware considerations. The topics we propose to cover, organized to make sense for learners, are:

1. Simple state machines. Example of activity: a lock that opens using a password;
2. Turing Machines. Example of activity: a machine that counts in unary or that draws patterns of colored symbols;
3. Create and program robot-pets. Example of activity: define and enact the behavior of a paper robot that moves and collects items;
4. Communication of images, introduction to Computer Graphics. Activity: send and receive an image by going from pixels to numbers and back;
5. Machines that generate random symbols. Activity: machine-generated music;
6. Programming of non-linear games. Activity: design, create and play a simple video game;
7. Scrambled communication. Activity: send messages with probability of errors, find ways to fix them at reception.

The actual conception order of these topics was: topic 2, i.e. Turing Machines, and topic 3, Robot-pets, then by way of simplification, state machines. Since we wanted some form of programming in our activities, but not necessarily coding or block-coding, we added topic 6, non-linear games, as a more software-oriented version of topics 2 and 3. Finally, to cover more than just visuals, we added topic 5, music generation. Topics 4, 5 and 7 are meant to show the pupils that multimedia (here images, audio and messages in general) are really just a matter of encoding and decoding of symbols, possibly with transmission channel in between.

We are aware that these seven topics might look very theory-heavy and are usually not an explicit part of CT, also considering that our target group is young pupils in primary school. However, according to some definitions (e.g. Tedre and Denning, 2016) CT learners should be presented with the basic concepts of the imperative programming paradigm: variables, conditionals, loops and functions. And it is well known in theoretical Computer Science that the imperative paradigm originated from Turing Machines. Furthermore, the simple kinds of automata we are considering in our activity book are based on test-and-jump rules, i.e. they require reasoning in the same way as with conditionals in CT, but with a more mechanical flavor than in programming. Moreover, we have been pursuing a surprising relation between theoretical Computer Science and tangible games for a long time (Valente, 2004), and here we maintain that many theoretical models of computation can indeed be turned into games, with rules and mechanisms, and manually emulated to better understand them; this is supported by the concept of notional machines, since in fact tokens and rules of a board game can represent the state and logic of a computational device, and act as a notional machine for such device.

Apart from imperative programming, CT also requires familiarizing learners with algorithms, foster problems solving skills, and working with data. The proposed topics in our activity book support this because they require iterative and algorithmic thinking, through design and enactment of the behavior of paper machines.

3.1 Exploring paper mechanisms

To be able to implement the topics in our activity book, we need paper-based mechanisms to: remember and change the state of a variable or a machine, generate random symbols, be able to jump from state to state, and to represent sequences of instructions/choices as physical objects. We explored a few possible ways to represent the state of a variable: a board with a marker, foldable tabs, a deck of cards, and a slider.

A board with a marker (see Figure 1.1) is a sheet of paper showing all possible values of the variable, and a marker-object to keep track of the current state. As an example, consider a Bingo card. This solution works only if a flat, horizontal surface is available, and requires markers as separate objects from the value sheet, which could easily be lost or mistakenly moved, resulting in loss of information about the state.

Foldable tabs (as visible in Figure 1.2). A sheet of paper with a linear sequence of possible values; one side of the sheet (possibly the top) has tabs that can be folded towards the values, to indicate which one is the current state. This solution works even if the sheet is a page of a book and has no
separate parts. However, the user has to remember that only one tab can be folded at any given time, so there is more possibility of human error than with the previous solution. A variation of solution 2 can be used when only 2 values are possible (see Figure 1.2B), and we call it foldable binary value.

A deck of cards solution is reminiscent of a physical display: a deck is printed with a card per possible value of the state. The user will simply stack the cards, being careful to maintain the top card on the deck as the current state of the variable (see Figure 1.3). This solution has the disadvantage of being less automatic, requiring some planning from the part of the user; moreover, the cards might require a horizontal surface to be usable and this solution, like the first, has parts that can be lost.

And finally, a slider: a popup paper device with a cursor-like part moving along a list of values (see Figure 1.4). The user slides the cursor up and down (or sideways if the orientation of the slider is horizontal). This solution is quite stable, automatic and has no separate parts, because the sheet of paper with the list of values cannot be removed from the cursor. A slider can be embedded in a book page if needed.

All of these solutions can be combined to describe more complex states. For example, two decks of cards can be stacked side by side, the first with cards from 0 to 4 and the second with cards from 0 to 9. These cards can be used to represent any number from 00 to 49, and the two cards in the two decks could be color-coded to avoid mixing them. Alternatively, two foldable tab sheets could be used, one with the digits from 0 to 4 as values, and the second with digits from 0 to 9.

For states that have many component values (called records or objects in Computer Science) a combination of various solutions could be possible: e.g. in an role-play game a character might be described by a foldable tab sheet with values "Warrior", "Mage" and "Rogue", followed by a slider showing the energy, with perhaps 5 values from "low" to "high", and a deck of cards representing which weapon, among a few available, is the character currently holding. The result would be a tangible dashboard, representing the complex state of the character at any moment during a game. Scirea & Valente (2020) discusses similar composite solutions found in board games.

Random generation is needed typically to simulate some level of Artificial Intelligence. The board game community offers many examples of tangible randomization solutions (Scirea & Valente, 2020).
usually connected to the need of defining behavior of interesting opponents, or to surprise the player by generating parts of the game on the fly, in unforeseeable ways (in computer games this approach is called Procedural Generation, and can be used with different contents, such as maps, images, characters, and even music). Here we are interested in methods to generate random values that can be used by primary school pupils, so they have to be very simple to deploy and use, but they can of course be based on probability or statistics; we just have to hide the complexity and the math and embed them in learner-friendly paper implementations. In our explorations we have recognized the following random generation mechanisms: fishing a card from a deck, chain-fishing, and pre-randomized tables.

Fishing a card from a deck is a simple mechanism that works like a die: the user has a deck of cards with one card per possible value, the deck gets shuffled, and the user fishes one card. The advantage of cards over dice is that cards can easily be added to the deck, altering the probability of fishing the possible values. For example, using a deck with cards “Dog”, “Dog” and “Cat”, the user has twice as many probabilities of fishing a "Dog" card than a "Cat" card. The main limitation of this approach is that the random values generated are independent of each other, i.e. the random generator has no context awareness.

To solve the problem of context of the previous solution, we can organize the cards in many decks, and let the first card fished decide which following deck will be used to fish the second card, and so on, i.e. chain-fishing. Consider the simple setup where we want to randomly generate all possible combinations of two decks: one, red deck, with cards "Dog" and "Cat", the other blue deck with cards "S", "M", "L" (i.e. the size of the animal). The user can be given two decks and fishing one card from each will provide any random pair animal-size. However, we might want to forbid certain combinations: perhaps for us dogs can be of any size, but cats can only be "S" or "M". To achieve this, we can duplicate the blue deck, obtaining the blue1 and blue2 decks, and remove some certain cards from each new deck. The blue1 deck will only have "S", "M", and "L", while the blue2 deck will have "S" and "M" only. And now we just have to associate each card in the red deck with one of the two new decks. The result will be three decks: the red deck with "Dog-blue1" and "Cat-blue2", the blue1 deck with all 3 sizes, and the blue2 deck with only small and medium sizes. The user will have to remember to always start by fishing a card from the red deck, then following the instruction of that card, fish a card from either the blue1 or blue2 deck. And this mechanism can be easily scaled to more values and longer sequences. Note that this solution is informed by Markov Chains, and allows the designer to create rather smart random generators that are still easy to use and do not require any math to operate. However, the user has to be careful to use the decks in the correct sequence and not to lose or mix cards; and it could be difficult to use this mechanism without a horizontal surface.

A pre-randomized table is a printed grid with certain values, eventually repeated and randomly positioned in the grid; without looking, the user points at the table with a finger or a pencil, selecting a random value. The main disadvantage of this mechanism is that there is no tangible representation of the generated values, so if the user has to generate and remember multiple values, she will have to keep notes using separate mechanisms. This solution is very easy to embed in books and can be used in a modular way by providing two or more pre-randomized tables side-by-side, and ask the user to use them in sequence. It is important to notice that even if the examples above use names or numbers, these mechanisms work perfectly also when a value is an icon or any symbol; so when designing a random generator for maps, the individual cards can simply be images of parts of a map (perhaps a tile with a river, one with houses, etc.). Finally, to be able to build paper computing machines we need ways to represent jumps in the flow of execution (called conditionals or IF-statements in CS) and sequences of instructions. Sequences of instructions are perhaps simpler to implement, since they can be realized by using the slider solution discussed in this section. Instead, jumps can be more complicated; in board games like the goose game, the board itself is divided into areas or cells and simple instructions are written in some of the cells. Those instructions can be to jump to a different cell or to perform certain actions (e.g. roll a die) to continue the game. From a Computer Science point of view, the board acts as a graph and graphs are indeed a classical way to represent the behavior of a computing machine (or in the case of the goose game a set of rules for a board game). However, graphs are a sophisticated notation that is usually introduced only at university level and requires specialized forms of algebra to correctly reason about. For instance, the state machines we want to present in our activity book are classically visualized as graphs in CS books. One of the main problems of working with tangible realization of
graphs, is that graphs might not be planar, meaning that there can be arrows (i.e. edges) connecting nodes (the states of the machine that the graph represents) in circular and intersecting ways, making it impossible to draw the graph on paper without any arrows crossing. Moreover, in a graph the physical distance among nodes is irrelevant, a property which is very difficult to represent with tangibles.

An alternative way to show a graph is to use a table. For example, the rules of a board game are typically expressed as a sequence of statements, possibly with conditions and consequent actions; those sequences can be mapped into a table with condition/action pairs, such as the following (or a graph in general):

\[
\text{IF condition}_1 \text{ THEN Action}_1 \quad \text{IF condition}_2 \text{ THEN Action}_2 \quad \text{etc.}
\]

A table like this can be written and given to the users of our paper computing machines, but in certain cases we might need the table to be changeable by the users. In this case we could implement a tangible version of the table by using two decks of cards (or two instances of our foldable tabs, like we discuss above). One deck will contain all condition cards, while the other deck has all possible actions; the user will just fish one card from each deck to create one row of her table. Interestingly, this mechanism can be used to both setup a fixed table of rules, but using reusable tangible elements (i.e. the cards) or to randomly generate strange, surprising tables that will result in strangely behaving computing machines.

3.2 Paper machines, scenarios of use, and discussion

Now that we have defined a few alternative ways to implement the state of computing machines, randomization algorithms, jumps and sequences instructions, in tangible form, we will present a few examples of designs for such machines: the Popup Turing Machine (PopTM in the following) and the Mintempo tangible game console (on the left and right respectively of Figure 2). A Turing Machine (TM for short) is a famous theoretical computing machine (invented by Alan Turing in his seminal 1936 paper), often considered the original conceptual model for all modern computers. A TM computes by using a tape where input symbols are written by the user, then it follows a list of simple instructions to read and re-write the symbols on a tape, producing a new series of symbols that constitute the output.

![Figure 2. Two paper computing machines: a paper Turning machine (left) and a tangible portable console that we call Mintempo (center and right).](image)
Our PopTM works in the same way: Figure 2 (on the left) shows the tape the machine, oriented vertically, with the input I00000 (the symbols as they appear from top to bottom). The program of this particular machine is very simple:

- Start from instruction A
- (A) if the current tape symbol is “I”, then rewrite it as “I”, go down to the next symbol, and stay, i.e. jump to instruction A; otherwise, rewrite the current symbol as “I”, go down to the next symbol, but jump to instruction B
- (B) if current symbol is “I”, then halt; otherwise, halt as well

The user will have to place the piece of paper representing the program under the first symbol on the top of the tape, with the program set to instruction A. Because the tape reads I00000, the computation will change it, step by step, until the machine halts and the tape shows II0000; so the machine started with one “I” symbol in input and halted with two “I” in output, hence, the machine added one to a number expressed in unary notation. It is easy to write new programs for the PopTM and calculate other mathematical or logical operations, such as additions or subtractions.

Even if the typical examples of use of a TM are mathematical, we have also designed examples in which the PopTM is used to change symbols in a more aesthetic way, or to work on letters and words. Our earlier experiments with CT sense-making and TMs are presented in Valente & Marchetti (2011). Here we propose an analogue and playful reinterpretation of TM, which aims at supporting shared sense-making in small groups of players through simulative forms of play (Gee, 2017, Vygotsky, 1978) encouraging them to enact the computational mechanisms of TMs, as if they were inside a TM, but without dealing with the algebraic formalism. In Valente & Marchetti (2011) we observed primary school pupils making sense together of the symbols and sequences of actions to be performed by the paper machine, hence supporting each other when encountering difficulties (Benton et al., 2019). Moreover, having explicit computational rules on paper, forced the players to articulate step by step the correct steps, eliciting in-depth reflections, instead of taking the system for granted as they would do with a digital game.

Figure 2 (on the right) shows a tangible, manually operated, game console that we call “Mintempo”, which in Danish sounds like “my own pace”. This paper machine is inspired by famous portable digital consoles such as the Nintendo Gameboy or DS, but instead of storing a game on a cartridge, we decided to use a deck of cards per game. The machine in Figure 2 has a game made of a deck with four cards; each card is numbered (from 1 to 4) and the lower part of each card has button-like jump instructions, which represent the program of the game. To play the game a player should start from card 1, and decide if she wants to follow the “skip->2” or “cut->4” instructions. Taking the “skip->2” option, the player will change the current card with card number 2, which shows the jungle grass growing, and provides other possible options. Choosing “cut->4” instead will send the player to card 4, which ends the game with a “fail” message, since there was no grass to cut at this point in the game. Looking at the cards from a CT point of view it is clear that they represent the program of the game and that they form a graph, with nodes (i.e. the cards) and edges (i.e. the jump instructions). Writing a game for the Mintempo console means then, to draw cards with all possible states of the game, and connect them together in a graph, by using jumps. The game mechanics emerge when a player executes the jumps in her preferred way. With Mintempo the players are encouraged to simulate on paper the experience of playing a digital game on an actual portable console, and also reason about embedded coding for that console. Our paper console leverages on game mechanics from card games, to suggest possible interaction and redesign of the system, combining play with design thinking. As for the PopTM, also in this case the goal is to lead players to simulate with each other (Gee, 2017, Vygotsky, 1978) gaming and coding experience afforded by digital systems. With both the PopTM and the Mintempo paper console, we aim at forcing players to articulate in detail the steps required to play a game, or reason about game design so that other players will take the appropriate steps and be able to play new games.

We propose to use these machines in class as support materials for hands-on tasks aimed at small groups of pupils engaged in shared sense-making. In this scenario, the teacher can prepare a few PopTM or give a working game (in the form of a deck of Mintempo cards) to a class of pupils, divided into small groups; the groups should be introduced to the machines using a use-modify-create approach,
where a working paper machine is constructed (from printed templates) together with the pupils, and then demonstrated. The pupils can then be asked to alter the machines, for instance by customizing them, by coloring or re-drawing them. Finally, the groups could be given tasks that need to create new machines, or new programs for their machines, and present/challenge other groups or the teacher(s). These are emergent forms of shared sense-making that we experienced before in our studies with Danish primary school classes, and they are usually associated with tangibles, tinkering and playful learning scenarios.

In more advanced classes the same type of scenario can be extended to include exercises, where the groups are asked to implement a digital version of their tangible creations, by using MIT’s Scratch or similarly suitable programming environments. A Mintempo game, for example, can be very easily digitized, by scanning the cards’ images into Scratch, and then by writing simple code that implements the jumps among cards, following the instructions in the tangible cards. We consider this as a way to bridge analogue with digital CT, as well as shared with individual CT, since the resulting digital games would have been developed as shared artefacts but played as single-player Scratch games.

The paper-based computational machines we designed for our PaCoMa activity book aim at providing support for affinity spaces (Gee, 2017), to enable the players to create their own world, in which simulate and reflect through social play and design thinking on computational concepts, which preexist the definition of current software and hardware. We see the emergence of shared affinity spaces as a precondition to support simulative play as well as providing room for negotiation and creation of meaning through the paper machines. Moreover, we aim at observing if through our paper machines, the players might achieve a meta-level awareness of CT’s fundamental concepts (such as variables, conditionals, loops, etc.): we would like to convey to our players/learners the notion that CT goes beyond a specific software or hardware system, and that the design of computational systems offers a lens to look at and understand problem solving in the modern world.

4. Conclusion and on-going work

Looking back at our experience with CT-related projects with schools and afternoon clubs, we believe that a DIY approach with cheap tinkering materials should work very well for early primary school pupils engaging in PL activities, targeting CT and support their teachers.

In line with constructivism, we believe that providing kits to build a computing machine out of paper, will foster feelings of empowerment and motivation, and provide greater understanding of CT topics. Our design of PaCoMa activity book can be seen as a prototype for a new kind of tangible materials, which have the potential to scaffold shared sense-making of CT, its principles and practices. We feel that demystifying computing machines and algorithms is perhaps the most valuable effect that CT can have on the new generation.

We are currently organizing tests of PaCoMa with our local and international network, and we expect to start in the coming fall semester. The tests will be conducted as qualitative studies (similar to what was done in Hsieh, Yi-Chun & Hou, 2015), adopting co-design with older learners in afternoon clubs and at the same time observing playing sessions with groups of younger pupils. The investigations will shed light on practical aspects of orchestration of classroom-wide play sessions with PaCoMa, to better support teachers, and help us better understand the interaction between tinkering with paper computing machines and existing school subjects.

References


Exploring the Effects of Card Game-Based Gamification Instructional Activity on Learners’ Flow Experience, Learning Anxiety, and Performance—A Preliminary Study

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Abstract: Game-based learning (GBL) and gamification for learning are trends in education nowadays. While most previous studies focused on the benefits of digital educational games, unplugged games, e.g., board games, have received relatively little attention. In contrast to computer games, unplugged games are more easily in the classroom as they generally cost less and rarely depend on technology. To explore the educational benefits in math of unplugged games, this study designed a card game-based gamification instructional activity to help students review and practice linear equation concepts. 143 seventh grade students from a junior high school in northern Taiwan participated this study. Students were randomly assigned to experimental group (n = 73) and control group (n = 70). This study compared students’ learning performance and level of math anxiety in both groups. In addition, students’ perceptions toward the game as well as their experience with the game were also collected. The results indicated that students in the gamification instructional activity showed better learning performance. Meanwhile, students’ math anxiety level was reduced after the gamification activity. Moreover, students generally reported positive experience with the game, which could be an indicator of students’ engagement. Implications of the results and future research are discussed.

Keywords: gamification, board game, math anxiety, linear equation, flow experience

1. Introduction

Game-based learning (GBL) and gamification have been widely discussed in recent years. GBL is known for its effectiveness in improving students’ learning motivation, attitude, engagement, and performance (Attali & Arieli-Attali, 2015; Sailer, Hense, Mayr, & Mandl, 2017; Subhash & Cudney, 2018). In general, GBL refers to the idea of using games for the educational purpose, e.g., serious games (for an overview, see Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012). Another common educational practice is the gamification of learning (Seaborn & Fels, 2015), suggesting that teachers apply game elements and game mechanisms into the learning activities, such as points, competition, and leader board. Antonaci et al. (2015) pointed out that applying games in learning could help learners become more active and motivated. The educational benefits of GBL and gamification have been well documented in the literature (Seaborn & Fels, 2015).

Many educational games have been proposed to improve students’ learning performance. Most previous educational literature on games generally focused on video or computer games (Coil, Ettinger, & Eisen, 2017; Huang & Levinson, 2012). Computer games provide visually appealing interface, prompt feedback, and dynamic interaction between learners and learning contents. These characteristics can be helpful in drawing learners’ attention and promoting their interaction with learning materials, thus leading to the better learning performance. Nonetheless, technology also has limitations in learning. First of all, developing educational computer games requires a lot of time and efforts in coding and artwork. Second, employing educational computer games in the classroom requires multiple digital
devices or the internet, and some schools may not have qualified equipments. Third, technology can be a distraction. With a multi-functional digital device in hand, students could be distracted by online contents that are not related to the learning activity.

In contrast to computer games, unplugged games, such as card games or board games, generally cost less and do not need technology. Unplugged games emphasize face-to-face interaction in a real world. In a learning context, the interactions among teachers, students, and learning materials are essential. In this manner, unplugged games might be helpful in facilitating students’ learning. For instance, Cheung and McBride (2017) showed that a special board game for math learning gave children multimodal cues to facilitate their number learning. Also, unplugged games have been implemented for supporting varied learning subjects, e.g., creative thinking (Chung, 2013), ecosystem concepts (Lin & Hou, 2016), environmental chemistry (Pippins, Anderson, Poindexter, Sultemeier, and Schultz, 2011), math competency (Skillen, Berner, & Seitz-Stein, 2018), and chemical compounds concepts (Wu, Chen, Wang, & Hou, 2018).

Game was considered an effective tool to promote students’ motivation and engagement in learning (da Rocha Seixas, Gomes, & de Melo Filho, 2016). A well-designed gamification instructional activity could create a gaming environment for players to interact with the game and other players. In addition, previous studies also suggested that instructors can use the process-oriented approach with games or activities to reduce negative academic emotions (Brunyé et al., 2013; Harper & Daane, 1998; Kim & Hodges, 2012). Learning new concepts can trigger different emotional arousal. Previous studies showed that academic emotional arousal included positive and negative affect, such as enjoyment, hope, boredom, and anxiety. (Linnenbrink-Garcia, Rogat, & Koskey, 2011; Pekrun, Goetz, Frenzel, Barchfeld, & Perry, 2011). For example, math anxiety could be one of the most well-documented negative academic emotions and it has been a critical issue in teaching math (González, Rodríguez, Failde, & Carrera, 2016; Hascher, 2010; Steinmayr, Wirthwein, & Schöne, 2014; Zeidner, 2014). Math anxiety could negatively influence students’ math performance (Ashcraft, 2002; Wang et al., 2015).

While previous studies have primarily focused on exploring the cognitive benefits of game-based learning, few studies so far have explored gamification instructional activities and the cognitive and affective outcomes. On the other hand, most previous game-based learning literature focused on the effects of computer games. This study, focusing on the potential benefits of unplugged games and gamification of learning, aims to explore the effects of an educational card game on students’ game play experience and their cognitive and affective outcomes.

Therefore, this study developed a card game- *Equation Troop* and designed a gamification instructional activity to help students review the concepts and calculation of linear equation. With the card game-based gamification instructional activity, the purpose of this study is to explore the following research questions:

1. Does the card game-based gamification instructional activity improve students’ learning performance in math?
2. Does the card game-based gamification instructional activity reduce students’ math anxiety?
3. Is there any difference between students’ math anxiety levels in the card game-based gamification instructional activity and in the conventional lecture?

### 2. Research Methods

#### 2.1 The design of the card game-based gamification instructional activity

This study developed a card game called *Equation Troop* to help students review and master concepts and calculation of linear equation. With the gamification of learning, the card game was expected to reduce students’ math anxiety. In the card game, players had to correctly solve the linear equation on the cards in order to recruit military forces to their troop. By the end of game, the players who successfully assembled the largest regiment (i.e., had the highest scores) would be the winner. Each card had a question of linear equation with one unknown on it. Each card also represented a troop of different size (i.e., scores). The size of the troop depended on the difficulty level of the questions.
Questions with higher difficulty levels represented larger troop size (i.e., higher scores). When the players correctly solved the equations within the time limit, they could recruit the troop to their regiment. In this game, the size of the troop represented the players’ scores in the game. Figure 1 shows the game cards of *Equation Troop*.

There are sixty cards of three difficulty levels, including the basic, the advance, and the master level. Questions of different difficulty levels had different points, i.e. one, two, five points for the three levels. The difficulty levels of the questions depended on the steps required to solve the equation.

Students worked in groups and played the game. The time for game play was 15 minutes. At the beginning, each group received three cards of three different difficulty levels. Students had to solve the linear equation for the correct answer by following the correct steps to earn points. When the players completed the three questions, they could ask the instructor for up to three more cards at a time. Students could ask for cards as many times as they wanted. Nonetheless, two-point penalty would be given for each unsolved equation when the time was up. Students needed to be careful when they asked for more cards and chose the difficulty level. Students in the same group were allowed to discuss on how to solve the equations. This mechanism facilitated social learning as students could learn from each other.

### 2.2 Participants

Participants in this study were 143 seventh grade students from a junior high school in northern Taiwan. Participants were randomly assigned to the experimental group and the control group. The experimental group consisted of 73 students (35 female) while the control group consisted of 70 students (36 female). In both the experimental and the control groups, students were grouped and five to six students were in the same group. The gamification instructional activity was employed in the experimental group. In contrast, a conventional practice learning activity was employed in the control group. Students in control group were given sixty linear equation questions, which were identical to the questions in the card game instructional activity. Students worked in groups to practice solving linear equations. Both the experimental group and the control group were instructed by the same math teacher. Before the instructional activity, students in both experimental and control groups have received lectures that introduced the concepts of linear equation. The lectures were taught by the same math teacher.

### 2.3 Measurement

This study adapted Killi (2006)’s flow scale to measure students’ attitudes toward the game elements and their gaming experiences in the card game and the gamification instructional activity. The flow scale consisted of twenty-two items from two dimensions, including the flow antecedents and flow experiences. Flow antecedents were the prerequisite characteristics of a task that led to the following flow experience, i.e., challenging, clear goals and feedback, sense of control, and playability. In this study, flow antecedents were used to measure students’ perception of the card game* Equation Troop*. On the other hand, in the flow experience dimension, the study measured students’ gaming experiences, including concentration, time distortion, autotelic experience, and loss of self-consciousness. The scale was measured with five-point likert scale.

To measure students’ academic emotion, this study adapted Modified Abbreviated Math Anxiety Scale (mAMAS), which was considered a valid and reliable measurement of math anxiety in
children and adolescents (Carey et al., 2017). The mAMAS consisted of nine items to measure respondents’ math anxiety based on a five-point Likert scale, from one (low-level anxiety) to five (high-level anxiety). Thus, if the respondent had high scores in the mAMAS, it meant that the respondent had high-level math anxiety. The Cronbach’s α of mAMAS was 0.933, suggesting a high reliability of mAMAS.

For student’s learning performance, a 15-item test was developed. The 15 items were evenly distributed to the questions of three difficulty levels; The test was firstly developed by an expert in math teaching, who had many years of math teaching experience in high schools. The test was then discussed and refined by the educational researchers of this study.

3. Results

This study conducted a series of tests to examine students’ learning performance, math anxiety, students’ perceptions of the Equation Troop and their gaming experience. The results are presented as follows.

First, Table 1 shows the results of learning performance in the control group and the experimental group. The experimental group, which used the gamification instructional activity, showed significant improvement (t = 5.09, p < 0.001). In contrast, the control group, which used traditional quiz practice, showed no significant difference between the pre-test and the post-test. Furthermore, this study conducted an ANCOVA test to compare learning performance between the two groups. With the pretest scores as the control variable, the results of ANCOVA showed that learning performance of the experimental group was significantly better than that of the control group (F(1,140) = 7.25, p < 0.01). These findings suggested that the gamification learning activity in this study promoted the students’ learning performance.

Table 1. Learning performance of the control group and the experimental group.

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<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control group</td>
<td>5.34</td>
<td>3.68</td>
<td>5.58</td>
<td>4.01</td>
<td>-1.20</td>
<td>72</td>
</tr>
<tr>
<td>Experimental group</td>
<td>6.57</td>
<td>3.41</td>
<td>7.51</td>
<td>3.62</td>
<td>-5.09***</td>
<td>69</td>
</tr>
</tbody>
</table>

Second, Table 2 shows the results of students’ math anxiety in the two groups before and after the activity. The experimental group showed a marginal decrease in math anxiety after learning with Equation Troop (t = -1.88, p = 0.064), and the control group showed no difference in math anxiety before and after the lecture. The study also conducted an ANCOVA test, with students’ math anxiety scores before the activity as the control variable. The results indicated that math anxiety was significantly reduced in the experimental group, but not in the control group (F(1,140) = 4.48, p < 0.05). These findings indicated that students’ math anxiety was reduced after the gamified math learning activity, not after the traditional practice session.

Table 2. Math anxiety (MA) of the control group and the experimental group.

<table>
<thead>
<tr>
<th></th>
<th>Pre-MA</th>
<th></th>
<th>Post-MA</th>
<th></th>
<th>t</th>
<th>df</th>
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<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control group</td>
<td>23.56</td>
<td>8.77</td>
<td>23.49</td>
<td>9.30</td>
<td>.090</td>
<td>72</td>
</tr>
<tr>
<td>Experimental group</td>
<td>20.43</td>
<td>8.69</td>
<td>18.90</td>
<td>8.73</td>
<td>1.88</td>
<td>69</td>
</tr>
</tbody>
</table>

Third, as for the students’ perception of the Equation Troop in terms of flow antecedents, students generally perceived the game as challenging (M = 3.94, SD = 1.05), controllable (M = 3.99, SD = 1.02), and playful (M = 3.69, SD = 0.98). They also thought of the game as have a clear goal (M = 4.29, SD = 0.85) and feedback (M = 3.90, SD = 0.93). The average scores in the sub-dimensions of flow antecedents were between 3.69 (playability) to 4.29 (clear goal), and they were all above the mid-
point of a five-point Likert scale (i.e., 3). As for flow experience, students generally had a positive flow experience (M = 4.00, SD = 0.82). The average scores in the sub-dimensions of flow experience were between 3.35 (lost of self-consciousness) and 4.21 (time distortion), and they were all above the mid-point of a five-point Likert scale, including experience of concentration (M = 4.09, SD = 1.00), time distortion (M = 4.21, SD = 0.90), autotelic experience (M = 4.14, SD = 0.93), and loss of self-consciousness (M = 3.35, SD = 1.10).

Fourth, Flow experience might be beneficial to both cognitive and affective outcomes (Csikszentmihalyi, 2014; Perttula, Kiili, Lindstedt, & Tuomi, 2017). Therefore, this study further explored the relationships among flow experience, learning performance, and math anxiety. As for learning performance, the results showed that students’ flow experience and learning performance were positively correlated (Pearson’s r = 0.477, p < 0.01). Moreover, the study explored the correlation between students’ flow experience and their math anxiety differences (i.e., the extent of anxiety reduction, pre-MA – post-MA). The results indicated that flow experience and math anxiety differences were positively correlated (Pearson’s r = 0.27, p < 0.05). This finding suggested that students who were more engaging in the gamification instructional activity also showed higher reduced math anxiety. This finding suggested a positive effect of gamification instructional activity on the anxiety reduction.

Lastly, in order to explore the possible gender difference, this study compared perceptions of the game and gaming experience between male and female students. There were no significant differences in both flow antecedents (t = 1.14, p = 0.26) and flow experience (t = 0.46, p = 0.65). These findings indicated that the game–Equation Troop was not particularly favored by a particular gender.

4. Conclusion and Discussions

The present study developed a board game–Equation Troop and designed a gamification instructional activity to help students review the concepts of linear equation and practice solving linear equation questions. Overall, the results showed that the gamification instructional activity significantly improved students’ learning performance in math. Previous studies suggested that game-based learning could promote students’ engagement in learning, and lead to better learning outcomes (Habgood & Ainsworth, 2011; Kiili & Ketamo, 2018). It seems that students’ engagement in the gamification instructional activity leads to their better learning performance.

In the present study, we also found that students who participated in the gamification instructional activity showed marginally reduced math anxiety; in contrast, the level of math anxiety in the control group remained intact. The math anxiety level between these two groups was significantly different. These results are similar to the results of previous studies that game-based learning help reduce learners’ anxiety (Mavridis & Tsiatos, 2017; Nuñez Castellar et al., 2014; Wu, Amin, Barth, Malcarne, & Menon, 2012). One possible explanation is that gamification instructional activity may change students’ perception of math learning, thus reducing their anxiety level. Unlike traditional math learning, the elements of games in game-based learning, such as points and competitions, may increase students’ motivation in learning and lower their anxiety (Mavridis & Tsiatos, 2017). And our findings supported the notion that gamification instructional activity could be an effective tool to promote students’ learning performance in math and reduce their math anxiety.

This study also adapted Kiili’s (2006) flow scale to measure students’ perception of the game (flow antecedents) and their gaming experience (flow experience) in the gamification instructional activity. The findings suggested that the students generally reported positive perceptions of Equation Troop, and they showed positive flow experience after the game. As Inal and Cagiltay (2007) suggested, boys and girls might have different game preferences. This gender difference might affect their degree of engagement in games and their learning outcomes. Nonetheless, in this study, the results showed that the game–Equation Troop was not preferred by any particular gender.

According to our findings, students’ flow experience was positively correlated to both their cognitive and affective outcomes. Specifically, the present study found a positive correlation between flow experience and learning performance. This finding suggested that the card game-based learning activity might foster student engagement and thus contribute to better learning performance (Csikszentmihalyi, 2014; Perttula et al., 2017). In addition to cognitive outcome, flow experience could
also contribute to student’s math anxiety reduction. Our finding indicated that students’ flow experience is positively correlated to the extent of their math anxiety reduction. In other words, students who experienced flow after the game, had lower math anxiety in general. This finding is similar to other previous studies (Hung, Huang, & Hwang, 2014; Isbister, Karlesky, Frye, & Rao, 2012; Mavridis & Tsiatsos, 2017). Mavridis and Tsiatsos (2017) found that game-based assessment could reduce students’ test anxiety. They suggested that the game mechanisms might make students feel like they were playing a game, not taking a test. In this study, our game mechanisms may change students’ perceptions of math learning. Nevertheless, further research is still needed to clarify what game features and how these features could contribute to math anxiety reduction.

In conclusion, our finding that game-based learning could foster students’ engagement and performance is consistent with literature. Moreover, students’ math anxiety level can be reduced. Although most students have math anxiety (González et al., 2016; Hascher, 2010; Steinmayr et al., 2014), it does not necessarily mean they have poor math performance. Harper and Daane (1998) proposed several ways to reduce students’ math anxiety, such as the process-oriented approach with games and activities and problem-solving group work. This kind of collaborative game play is an essential element of board games. The present study demonstrated a card game-based instruction approach, which could be easily implemented in the classroom. In contrast to computer games, which generally require expensive digital devices and may cause distractions to students (Goundar, 2014), the unplugged game used in this study encourages collaborative work and real-world interaction. It also helps promote students’ learning performance.

4.1 Research Limitations and Future Research

As an exploratory study, the present study has several limitations, which should be taken into consideration when interpreting our findings. First, the sample size of this study was limited. Future research could explore the relation between students’ engagement and anxiety reduction with a larger sample size. Furthermore, future research could investigate how a gamification instructional activity could lower students’ anxiety in different learning subjects, or how it could lower different kinds of learning anxieties, e.g., test anxiety.

Second, this study used self-reports to measure students’ flow experience and math anxiety. While self-reports are commonly employed in previous studies, it could be influenced by social desirability bias (Dettmers et al., 2011). Future research could use bio-feedback device to measure students’ responses. For instance, Mavridis and Tsiatsos (2017) employed a bio-feedback device and collected learners’ physiological signals to interpret their test anxiety level. Similarly, Wouters, van Nimwegen, van Oostendorp, and van der Spek (2013) suggested researchers use objective measures, such as physiological or behavioral indicators, to measure the level of students’ engagement in serious games. However, bio-signals might be inaccurate due to device constraints. Therefore, data triangulation by combining subjective measures (e.g., self-reports) and objective measures (e.g., bio-signals) would increase the validity of measurement and help explore students’ behaviors and responses in gamification instructional activities.

Third, this study adopted the flow scale developed by Kiili (2006) to measure students’ flow experience. Flow was found to be positively correlated with motivation (Chang et al., 2012). Nonetheless, the present study did not specifically measure students’ motivation. Game is known for being able to enhance learning motivation (Deterding, 2011), and motivation could subsequently lead to engagement in learning and better learning performance (Chang et al., 2012). Future research can explore the changing motivations of students in games. It can also compare students’ behavioral patterns based on different motivation levels or flow experience with sequential analysis (Hou, 2015). These research approaches would help us better understand the relationship between game designs and motivation.

Last, the present study demonstrated positive effects of gamification instructional activity on learners’ learning performance and anxiety. Nonetheless, with the rapid development of information technology, novel technology can be applied to improve students’ learning outcomes. For example, augmented reality (AR) technology has been widely discussed in recent years. Recent studies also showed the benefits of using AR for education (Akçayar & Akçayar, 2017). For example, Chen (2019)
found that learning math with AR could reduce students’ math anxiety and promote learning performance. AR augments real-world experiences with virtual objects, such as digital 3D objects, texts, or graphs, thus creating a novel experience for players. Since playing board games is a real-world experience, combining board games with AR technology might bring a more advantageous learning experience and better learning outcomes. Therefore, future research is encouraged to investigate the effects of combining board games and AR in education.

Acknowledgements

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Supplementing Elementary Science Learning with Multi-player Digital Board Game: A Pilot Study

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Abstract: Educational games or serious games are playing an important role to facilitate today’s student learning preferences and promote their motivation to learn in subject contents. Currently, many researchers revealed that digital game-based learning could promote students' motivation and their interest for learning by addressing abstract and complicated concept with mechanics of game. To examine a preliminary effect of supplementing primary school students’ learning in science, a multi-player digital board game has been created and then implemented to 6 third-grade students (1 male and 5 females) in a local public school in the northeastern part of Thailand. They received the board game learning experience in a 100-minutes supplementing activity after their completion of conventional science lesson on living and non-living things. The results showed that they positively accepted the learning and playing with digital board game in general science topic about living things and non-living things. Furthermore, the students expressed positive perception towards the learning by playing with the digital board game. The main contribution of this study using digital board game-based learning to enhance students learning perception in science learning.

Keywords: digital game, game-based learning, educational game, collaborative inquiry, perception

1. Introduction

The advancement of digital technology in education could be used to promote authentic and active learning for new generation learner. In recent years, educators, researchers, developers, and teachers have attempted to apply digital game technology to create edutainment learning environment by adding educational purposes into digital games that are educational games or serious games (Cheng et al., 2013). Digital game-based learning is a pedagogical type of constructivist-oriented learning approach that has positive learning outcomes for students. According to the popular of digital game and its important role in our society, particularly younger generation or children who like to play game as a favorite, many studies have demonstrated that educational digital game could be used to promote student learning performances and their learning motivation (Wang & Chen, 2010; Liu & Chu, 2010; Harris & Reid, 2005). In the same way, Sung and Hwang (2013) collaborates a game-based learning environment by integrating a grid-based mindtool for students to share and organize during the game-playing process. Moreover, developing game-based learning could enhance students’ motivation, perception and learning outcome in science class (Meesuk & Srisawasdi, 2014; Kitchawalit & Srisawasdi, 2015; Hiangsa, Srisawasdi, & Feungchen, 2015; Kanyapasit & Srisawasdi, 2014; Srisawasdi & Panjaburee, 2019). These results revealed that the pedagogical applications of educational digital game could enhance not only students’ learning achievement but also their attitude towards learning and motivation to learn in science courses.

Due to the growth of digital technology in today’s society, digital board game is one of learning technology that used to engage today students’ learning, and also foster their motivation and interest in the learning of content subjects (Agca & Özdemir, 2013). The potential of digital board game in order to promote students’ attitudes toward learning and increase their learning performance has been mentioned by educational researchers and developers. In the learning with digital board game, it is similar to playing with a computer game that can make student learning more enjoyable and challenge
in order to accomplish their own learning. The term of digital game refers to any game played using electronic device that employs consistent rules or constraints, has a clear goal, provides feedback and monitors progress via scores or other methods. The digital board game made of a game board, illustration cards, a text description, and some digital characteristics that players could use to interact with the game. In addition, a digital board game provides an interactive and interesting platform for learner. For instances, Zheng, Cheng and Chen (2018) integrated board game into computer software (called organ savior game) to explore students learning effectiveness in the health and physical course. These results showed that using organ savior game can enhance students’ learning achievement. By the way, Juñior, et. al (2020) designed a board game consisting of one physical board, a few cards, and one mobile application about the reactions of organic compounds. The result of this study indicated that this kind of game could be effective learning tool to support students better learning in the organic reactions. Furthermore, using a digital board game in vocabulary languages learning can enhance students’ learning interest (Ali, et al., 2018). Consequently, digital board game seem to be a pedagogic choice as technology-enhanced science learning that could apply to promote students’ learning in science-oriented concepts. As such, it should be utilized as pedagogic learning tool in order to transform and create an innovative learning approach in science education.

2. Literature Review

2.1 Game-based Learning in Education

In the last decade, several researchers have attempted to integrate content knowledge with games for learning that calls educational games or serious games (Sorensen & Meyer, 2007; Stone, 2008). Using games in education has demonstrated positive learning outcomes. For example, Hsu, Tsai and Wang (2012) investigated the effect of using a computer game with the self-explanation principle in elementary school about light and shadow. This finding showed that students have a high-engagement in terms of the posttest and the retention test. In the same way, game features could affect the development of children's engagement (Ronimus et. Al., 2014). Furthermore, various studies have explored students’ motivation by using the game in education. For instance, Huizenga, et. al., (2009) used a mobile game that calls Frequency 1550 in education integrated situation with active learning to enhance students' motivation and historical knowledge for History in general and the topic of the Middle Ages in particular. Similarly, Gamlo (2019) demonstrated that the use of mobile-game based language learning applications (MGBLLAs) could improve student's motivation to learn English.

2.2 Digital Board Game in Education

Recently, many different types of educational games are used and applied for learning in school. The board game is one of the educational games to enhance students' motivation, perceptions, and participation of learning in the classroom. Moreover, many researchers have developed a board game with digital technology suitable for students in the 21st century. Zheng, Cheng, and Chen (2018) used an electronic board game called organ savior game to teach health and physical education for elementary school students. This research demonstrated that students could enhance learning achievements in learning human internal organs and health information. Using a digital board game for the purpose of vocabulary learning in language can supports students to learn vocabulary (Ali et. al., 2018).

According to the aforementioned, Digital board game is an essential educational tool for all student to relate with content knowledge and provide students interaction through physical devices to develop students' knowledge learning. Furthermore, integrating a learning subject with a digital board game can improve students' learning affectiveness. For instance, Wu, Chen and Huang (2014) provided a digital board game language learning set for English classroom learning. This study found that instruction could be improved communicative skills and intrinsic motivation for EFL language learning. Consequently, our research attempted to integrate a digital board game with content knowledge to apply for classroom learning.
3. Research Methodology

3.1 Research Design

The one-group posttest only design was set up to study the effect of using game-based learning with a board game for science learning about living things and non-living things. This research used qualitative methodology as the study platform. Qualitative research methodology within phenomenological research design was used to explore primary school students’ perceptions towards supplementing science learning with digital board game.

3.2 Participants

The participants of this study were six third-grade students (one male and five females), age ranging from 8-9 years old in a university-based school located in the northeastern region of Thailand.

Research Instruments

An interview protocol has been developed for this study regarding the theory of Technology Acceptance Model (TAM) in order to examine students’ learning perception after interacting with a supplementing digital board game created by the authors. (Davis, 1993)

Data Collection and Analysis

The preliminary study has been conducted in a primary school science course, in a topic of living things and non-living things, by the first author. Figure 1 illustrates the experimental method of this pilot study. As showed in the Figure 1, the science teacher, the first author, introduce a conceptual summary of living and non-living thing lesson to the students. Then, an introduction of how to play and learn with a proposed digital board game, shortly called Living or Not game, and its playing rules has been presented by the teacher. The students were allowed to interact with the game in group as multi-player approach and turn-based playing. Before ending the class, the teacher and students collaborated in a conclusion about the living and non-living things concepts by recalling what they received during the game and classifying them into living or non-living things. After completing the proposed lesson, all students took a post-interviewing to measure their perceptions for 10-15 minutes each.

![Figure 1](image_url)

*Figure 1. An illustration of the experimental procedure of this study

Game Design – Living things and Non-living Things*
The design of the game is similar to the well-known snake-ladder game, which is a kind of common game made for board game and used by two or more players. Ladder snakes are interesting game that use dice to define how many steps a box has to go through. The researchers designed game attributes and its mechanics and rules following the snake ladder game for producing the Living or Not game. With the support of mobile technology, the Living or Not game is an interesting digital mobile game in a combination of board game, card game, and digital game by their nature.

For the Living or Not game, there are 30 scannable cards consisting of two types of cards: living things cards and non-living things cards. To begin the game, all players have to put their pieces in the starting position on the gameboard. Afterward, to get a card, the players have to roll the dice and go to a piece obtained. Then, the players can open a card as a piece picture obtained via the game, and the image on each card is connected with a specific mobile application for the game, which could be scanned and see the selected things by this mobile application, on mobile device’s screen which this research used IPAD device. The board of the game consists of 30 boxes inside. There are many pictures of cards about living and non-living things in the boxes. Moreover, there is a conceptual question for each card displaying after the user scanning by mobile application. If the players answer correctly, a reward would be presented on the mobile application. On the other hand, if the player answers wrongly, a punishment would also be presented as well. Figure 2 shows an example of gaming steps by using the digital board game.

The content in the Living or Not game is about the theme of living things and non-living things. The board game development is focused on playing about the characteristics of living and non-living things. As such, players would learn to know different characteristics and how to classify a type of living and non-living things as the contained in each card. In the game, there are seven characteristics; growing, reproduction, breathing, eating, moving, responding, excretion. The game step is performed by the player in turn until one of the players successfully place on the last box and say the word “Finish”, or the teacher limited the timing to play with the game. Figure 3 of a learning process by using digital board game.

Furthermore, the Living or Not game has been designed for students in multi-player style and turn-based task. Therefore, they can play it in groups or individuals in the classroom or even playing with their parents at home.
4. Research Result and Discussion

This study purposes to examine primary school students’ perception towards a supplemented digital board game in a science class. This study demonstrates its qualitative findings regarding the students’ perception. Meanwhile, data that was collected qualitatively; more specifically interviews, were coded. Thus, the results of the study “S1” refers to “Student 1”, “S6” stands for “Student 6”, respectively.

Generally, these results show an important need for a digital board game in science learning. These results demonstrated that participants provided positive feedback when asked about their views on the use of a digital board game in their science learning. The students provided positive comments when asked about their views on the use of a digital board game in science learning.

From the view of Technology Acceptance Model (TAM), perceived ease of use, perceived usefulness, user satisfaction and attribute of usability are supposed to be related to using digital board game in science learning. Moreover, researchers adapted the TAM to consist of learning aspects and playing aspects after interacting with the digital board game. From table 1, the Item 1 about learning perspective, one of the students explained that “Yes, a game has information about the characteristics of living things. For example, a human can reproduction or evolution”. The perspective was reflex by S1, S5, and S6 in which they felt that "I can know that what is living things or non-living thing". Item 2, the view was commented by S1, S2, S4, and S6, they believed that “Yes, it [digital board game] is useful. We can answer questions, for example, Can it move?, Can it reproduce? Can it excrete? and so on”. Item 3, S2, S3, S5, and S6 noted that “It [digital board game] is easy because i can divide about characteristics of living and non-living things through IPAD”. Item 4, all of students mentioned that “This game is good because it has knowledge”. Item 5, one of the students alluded that “Sure, because i like to use a smartphone on learning”. In the same way with S1, S2, S4, S5, and S6 mentioned that "I want to play a game again". The learning of living things and non-living things through digital board game learning environment supports to learn by themselves.

Table 1. Perspective of Students’ Perception with Digital Game Based Learning

<table>
<thead>
<tr>
<th>Items</th>
<th>Perspectives</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Learning</td>
<td>Do you think a game could be a tool for learning science by yourself? Why or why not?</td>
</tr>
<tr>
<td>2</td>
<td>Learning</td>
<td>Do you think the game can support your learning about living things or non-living things? How?</td>
</tr>
<tr>
<td>3</td>
<td>Learning</td>
<td>Do you think it is easy to learn about living things or non-living things by using the game? How?</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Does the game is good for your learning experience? How?</td>
</tr>
<tr>
<td>Items</td>
<td>Perspectives</td>
<td>Questions</td>
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</tr>
<tr>
<td>5</td>
<td></td>
<td>If you need to learn about living things or non-living things, will you use the game? How?</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Do you think a game could be a tool for playing science by yourself? Why or why not?</td>
</tr>
<tr>
<td>7</td>
<td>Playing</td>
<td>Do you think the game can support your playing about living things or non-living things? How?</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>Do you think it is easy to play about living things or non-living things by using the game? How?</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>Does the game is good for your playing experience? How?</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>Do you think it is a tool that can use to play the game? How to play?</td>
</tr>
</tbody>
</table>

For the playing perspective after interacting digital board game, these results showed Item 6, “Yes, I can because it [digital board game] enjoys because we can think and see a card by ourselves through the iPad” as mentioned by S1, S3, S4, and S6. For item 7, As S1, S2, S4, and S6, they believed that “This game has useful because we can play and learn together”. The view of item 8 was echoed by S1, S3, S4, S5, and S6 in which they felt that Student A “It [digital board game] is easy to play because we just roll the dice and use the iPad to play a game”. S5 referred that “It [digital board game] is very good because it [digital board game] is enjoyable and easy to play.” for the view of item 9. For the last item, S2, and S5 noted that “Yes, i can play with my younger brother. I can teach him how to play a game.”

This qualitative study was shown students’ perception of digital game-based learning using the Technology Acceptance Model. This study also found that students perceived digital board game as fun and interactive tool. In addition, digital board game can be played at spare time, play with family or friend, review science content after the learn finished and makes learning a fun process. Related to a previous study indicated that the participants mentioned that digital learning can promote the experience more enjoyable and interesting (Mora, Loreto, & Divitini, 2016). Similarly, Chik (2014) demonstrated that playing a game with other communities of players could extend students’ vocabulary and enhance students’ language skills. Furthermore, by developing the digital board game, the game is improved with several visual and sound which makes it a good educational tool that promotes pleasure, enjoyment, and motivation of students (Sahrir, Zainuddin, & Nasir, 2016). These finding could use to refine on digital game-based lesson that encourage better student learning.

5. Conclusion and Future Study

In this study, researchers purpose to investigate the perception of a digital board game among elementary students in science learning specifically in living things and non-living things. From the results, it seems clear that most students believed that digital board game could enhance their knowledge about living things and non-living things. They have positive perception to the digital game-based science learning with a board game. Based on the results of this study, it is presented that the digital board game has a great tool for support more innovative science classroom education method in 21st century. According to the preliminary findings, the researchers will design board game-based learning with appropriate pedagogy to promote students’ learning performance in the next study.
Acknowledgements

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Prototype of Paper Map for Practical Use of Regional Safety Map "Hamādo-map" and Its Questionnaire Survey

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Abstract: This paper describes making and evaluation of a paper-based regional safety map using the information of our community-based safety map creation support system. The purpose of this paper map is to raise awareness of disaster prevention by recognizing danger information in the local area on a daily basis. We extracted danger information from our system and imported it into an electronic map book Zi20 of Zenrin Co., Ltd. In addition, we have changed designs of icons displayed in the map and the information on hazardous areas. We have also added disaster prevention facilities and useful information in the event of disasters. These contributed to the creation of the A2 size regional safety map "Hamādo-map". We clarified issues for practical use of our safety map by conducting a questionnaire survey on the local residents in the target town and the city officials involved in disaster prevention in this area.

Keywords: regional disaster prevention, safety map, voluntary disaster prevention, historical local town, community participation

1. Introduction

Many efforts have been made to deal with natural disasters that frequently occur in recent years (Disaster Management, Cabinet Office, 2015; Geospatial Information Authority of Japan (GSI), 2017; ICTDSE2019 in ICCE2019, 2019; Mitsuhara, H., 2018). Hazard maps are attracting attention as a countermeasure against them. However, in local towns with historical streets (historical local towns) (Japan Guide.com, 2012), there are dangers in places such as old houses, narrow roads, and small waterways that do not appear as a standard when making hazard maps. It is desirable that these dangers are revealed from the perspective of local residents.

We set Hizen-Hamajuku, Kashima City, Saga Prefecture, where old townscapes from the Edo period remains, as a model district (Agency for Cultural Affairs, 2017; Saga Trip Genius, 2014). We have been working on practical development research on a system that supports creation of a regional safety map using ICT in cooperation with local voluntary disaster prevention organizations (Okazaki, Y., et al., 2016; 2017; 2018; 2019). The purpose of our project is not just making local disaster prevention maps but clarify the design of sustainable safety map creation that takes into consideration the information provision method and the validity of the information in collaboration with the local residents.

In this study, we create a paper-based regional safety map based on the danger information collected in cooperation with the community as part of the district's voluntary disaster prevention activities at Hizen Hamajuku selected as a model district. We clarify issues for practical use of the local safety map by conducting a questionnaire survey on general local residents and the city government officials involved in disaster prevention in this area.

The rest of this paper is organized as follows. Section 2 introduces our regional safety map. Section 3 describes results and discussion of the questionnaire survey. Section 4 gives summary of the paper.
2. Regional safety paper map "Hamādo-map"

2.1 How to Make the Map

Figure 1 shows the flow of the map creation process. We used an electronic map book Zi20 of Zenrin Co., Ltd. to create the map. We extracted the information (danger type, location information) of the dangerous spot collected by the previous activities from the database of our community-based safety map creation support system (CSV output) and imported them into the electronic map book Zi20. In addition, based on the results of previous questionnaires, the designs of icons indicating danger information were modified. The information of dangerous areas spread over certain areas was manually drawn and input while referring the program as Zi20 graphic information, because these are built into the system. Furthermore, description of icons (fire, flood, earthquake, and other dangers), information on low-lying land that is easily flooded, paths that may become inaccessible in the event of an earthquake, roads that fire truck cannot pass, and useful information for evacuation during a disaster are provided. This information was integrated and output as Zenrin's voluntary disaster prevention map (A2 version).

2.2 Overview and Components of the Map

Figure 2 shows the prototype paper map version of the regional safety map "Hamādo-map". This map provides information with icons and graphics based on Zenrin's map information. The danger location information is displayed with four types of icons (Fire, earthquake, flood, and other dangers). The information is 14 of the information collected by the local residents who walked around the town, which was determined to be high risk. As information on the dangerous area, a total of 39 pieces of information are drawn as graphics on a map. It includes flooding caution areas, densely-built wooden house areas, fire-sensitive areas, earthquake caution areas with soft ground, narrow paths that may be impassable when an earthquake occurs, and paths that fire trucks cannot pass through.

In addition to the data from our community-based safety map creation support system, three new evacuation centers (icons) and disaster prevention information useful in the event of a disaster (checklist for items taken out when evacuating) are provided.

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**Figure 1.** Flow of the map creation process
3. Questionnaire Survey

3.1 Survey Method

A questionnaire survey was conducted from January 16 to 24, 2020. The subjects were 21 local residents of Hizen-hamajuku who came to the morning market or Hizen-Hama station, and 12 officials of Kashima City. We have not identified the respondents. Of the 21 respondents, 8 have experience using electronic maps. This indicates that they participated in map making or map-based workshops. The remaining 13 are believed not to be involved in our project.

The survey items of local residents are 14 items, which include age and gender, relation to our previous activities, comparison between paper maps and electronic maps, visibility and comprehensibility of maps, validity of information, and practicality of maps. The ones of the city officials are five items such as the visibility and comprehensibility of the map and the points to be improved in addition to their affiliation and recognition of our activities so far.

3.2 Survey Results

3.2.1 Results for Local Residents

A comparison between paper maps and electronic maps showed that two-thirds preferred paper (Table 1). Although there was demand for electronic maps, paper maps were generally preferred. About 80% have a positive evaluation of visibility (Table 2). On the other hand, for the comprehensibility, the icons, risks, and other description were not sufficient, indicating that there was room for improvement (Table 3).
About the validity of the information, about three-quarters affirmed that it contained nearby hazard information that was not included in the hazard map (Table 4). On the other hand, there were negative opinions such as "There is little information described" and "There is no information that I think is dangerous". This suggests that it is necessary to review information collection and evaluation.

More than three-quarters positively evaluated the practicality (Table 5). The map was evaluated as useful for preparing for a disaster or for raising awareness of disaster prevention on a daily basis. This indicates that the practicality was able to obtain a certain appreciation.

### 3.2.2 Results for City Officials

Regarding visibility, only one-third of positive evaluations were made (Table 2). As for the comprehensibility, it was clarified that there was room for improvement in the comprehensibility of risks, descriptions, and the comprehensibility of icons, similar to local residents (Table 3).

---

**Table 1. Comparison of Preference Between Paper Map and Electronic Map**

<table>
<thead>
<tr>
<th></th>
<th>Paper Map</th>
<th>Electronic Map</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which is better, paper map or Electronic one?</td>
<td>62.5%</td>
<td>37.5%</td>
</tr>
</tbody>
</table>

**Table 2. Visibility of Offered Information**

<table>
<thead>
<tr>
<th>(Visibility)</th>
<th>Agree</th>
<th>Somewhat Agree</th>
<th>Neither Agree nor Disagree</th>
<th>Somewhat Disagree</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you think the map is easy to see?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local Residents</td>
<td>31%</td>
<td>50%</td>
<td>13%</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>City Officials</td>
<td>9%</td>
<td>27%</td>
<td>36%</td>
<td>27%</td>
<td>0%</td>
</tr>
</tbody>
</table>

**Table 3. Comprehensibility of Offered Information**

<table>
<thead>
<tr>
<th>(Comprehensibility)</th>
<th>Risk</th>
<th>Color</th>
<th>Font</th>
<th>Supplementary Description</th>
<th>Icon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Please choose the items that you think is easy to understand or appropriate.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local Residents</td>
<td>18%</td>
<td>43%</td>
<td>18%</td>
<td>14%</td>
<td>7%</td>
</tr>
<tr>
<td>City Officials</td>
<td>0%</td>
<td>33%</td>
<td>42%</td>
<td>0%</td>
<td>25%</td>
</tr>
</tbody>
</table>

**Table 4. Validity of Offered Information**

<table>
<thead>
<tr>
<th>(Validity of Information)</th>
<th>Agree</th>
<th>Somewhat Agree</th>
<th>Neither Agree nor Disagree</th>
<th>Somewhat Disagree</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you think the map offer danger information felt in daily lives?</td>
<td>36%</td>
<td>29%</td>
<td>21%</td>
<td>7%</td>
<td>7%</td>
</tr>
<tr>
<td>Do you think the map offers you more information than official hazard maps?</td>
<td>37%</td>
<td>38%</td>
<td>13%</td>
<td>6%</td>
<td>6%</td>
</tr>
</tbody>
</table>

**Table 5. Practicality of Offered Information**

<table>
<thead>
<tr>
<th>(Practicality)</th>
<th>Agree</th>
<th>Somewhat Agree</th>
<th>Neither Agree nor Disagree</th>
<th>Somewhat Disagree</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you think the map is useful for evacuation in case of disaster?</td>
<td>50%</td>
<td>25%</td>
<td>19%</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>Do you think the map helps raise disaster prevention awareness ?</td>
<td>57%</td>
<td>29%</td>
<td>7%</td>
<td>0%</td>
<td>7%</td>
</tr>
</tbody>
</table>
We also received opinions and comments from the perspective of disaster prevention in this area. These include design of descriptions and icons, etc. so that the danger information on the map can be clearly conveyed, addition of evacuation routes assuming actual evacuation, and enhancement of posted information such as addition of useful telephone numbers in the event of a disaster.

3.3 Discussion

3.3.1 Visibility and Comprehensibility

This safety map aims to convey local danger information in an easy-to-understand manner. Residents say that it is generally easy to understand, but about a quarter of city officials are negative (Table 2). The evaluation of the printed information indicates that there is room for improvement in the way of conveying danger information, such as easy-to-understand risks (design of icons and graphics) and supplementary information for danger description and evacuation (Table 3). An analysis of the free description revealed that in addition to display problems such as the design of the icons and the colors of the areas at risk, the explanation of the meaning of the icons and the meaning of the location was insufficient.

The notation system has been used and shared so far by members of the district’s voluntary disaster prevention organization through the activities. For the general public without such experience, it seems that there were parts that could not be easily understood. As a countermeasure, it is necessary to clearly explain the meaning of the information to be displayed in words, and to clarify the intention of the danger information described in the location. After that, the design of icons and other graphics for danger should be improved to make the contents intuitive and understandable.

3.3.2 Validity

The danger information in the safety map was reviewed at meetings of the local disaster prevention organization. From the danger information collected by local residents actually walking around the city with tablet terminals and the danger information newly added at meetings with the voluntary disaster prevention organization, danger information determined to be high risk at the meetings of the voluntary disaster prevention organization is printed.

We believe that we were able to collect a certain amount of information by collecting the information pointed out by the residents of each district while walking their own district. However, only one-time town walk for the entire district was conducted. In addition, it has been pointed out that the new dangers were noticed and some dangers were removed by countermeasures. We also found that there were individual differences in how people perceive danger. Based on these facts, it is necessary to periodically collect and inspect danger information as local disaster prevention activities, and to update the map while sharing the danger information in the region.

3.3.3 Practicality

This regional safety map was created with the focus of providing the collected danger information and raising awareness of disaster prevention. Since it is created on an A2 size paper map, it can be said that it has a high degree of browsing, and it has a certain level of practicality in raising awareness of nearby danger (Table 5). On the other hand, some respondents suggested that information such as evacuation routes, telephone numbers prepared for disasters, and information on evacuation should be added from the viewpoint of use as disaster prevention maps. In the future, it will be necessary to organize information that leads to actions after recognizing nearby dangers and print them in an easy-to-understand manner.
3.3.4 Differences in assessment between residents and city officials

There were differences in assessment between residents and city officials. We suppose the reason why the city officials evaluate lower than residents is they are in a position to protect the lives of residents. They are supportive of our project. We believe that the strict evaluation is due to strong expectations for practical and useful mapping of residents’ perspectives.

4. Conclusion and Future Works

In this study, we created a regional safety map of A2 size paper map using the information of the community participation type local safety map creation support system, and evaluated it through a questionnaire survey. This regional safety map provides local danger information collected using tablet devices as local voluntary disaster prevention activities and the information pointed out at the voluntary disaster prevention meetings. As a result of conducting a questionnaire survey of local residents in the target area and city hall officials involved in disaster prevention in this area, the map received a certain rating in recognizing the danger information of the area by looking at the map and raising their awareness of disaster prevention. On the other hand, it became clear that there was room for improvement in the comprehensibility, validity of the printed danger information. In addition, we were able to obtain opinions and comments from the city officials involved in disaster prevention in this area, regarding the information provided, adding new information, and improving the supplementary information for danger description in the map.

As a future task, it is necessary to improve the comprehensibility of icons that indicate danger information and graphics of information on danger areas so that danger information is clearly recognized. It is also necessary to collaborate with local voluntary disaster prevention organizations to collect and select new information to be printed. Based on these, we will make improvements to include information that will lead to actual disaster prevention and evacuation actions.

Acknowledgements

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References


Model of Video Aided Retention Tool for Enhancing Disaster Survival Skills on Earthquake among International Students

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Abstract: The purpose of this research is to design an integrated video-based learning support system to provide training on earthquake Disaster Survival Skills (DSS) among the international students in the universities in Japan. The available literature shows a significant gap in the field of earthquake disaster survival skills between Japanese and international students. There are different types of contents used in DSS education and training. Among them, video contents received broad interest from the students in a self-directed video-based learning environment. However, in Japan, DSS video content specially designed for international students is limited. Often many topics are included in a single video, making the content long volume. So, arranging the essential parts inside the video with meaningful indexes and representing them in a logical order to keep the students’ motivation is important. Also, filtering and recommending more important content to fill the empty knowledge of the students is essential. In addition, tracking and analyzing students’ learning behavior inside video parts including the attention and retention process to support them during learning is equally important. Accordingly, the research designed the essential models of the VART system to accomplish such requirements. The proposed VART system is the combination of video fractioning, indexing, tracking, analyzing, and filtering tools, with the integration of domain model, students’ model, and e-teaching strategy model to assist in self-directed video-based learning. The system organizes and makes fractions of each video into different important parts and put automatic indexes for each fraction. It also tracks each student’s ID, content preferences, duration, repetition of the content, most watching parts, etc. Based on the detailed watching history data VART analyzes and determines each student’s learning needs and filters and delivers essential video parts sequentially to support the video-based learning process.

Keywords: Video Aided Retention Tool (VART), Disaster Survival Skills (DSS), Learning Technology, Video-based Learning, Earthquake

1. Introduction

Disaster Survival Skill (DSS) training for students is considered as mandatory criteria to reduce the risks and increase the survival capacity during the disasters. However, many researchers identified that a huge number of international students studying in Japanese universities have little or no prior knowledge and skills on how to survive in a disaster situation, especially in the earthquake (Emanuel Leleito et al., 2016). To reduce vulnerability, providing DSS training on earthquake to international students is considered a mandatory part of disaster education. So, a well-designed and target-oriented DSS training on earthquake is very important for them to increase their awareness and preparedness, and enhance their survival skills to prepare and tackle any catastrophe during an earthquake.

In Japan, disaster education is provided elaborately to primary and secondary school students in their native language. As a result, Japanese students are well-trained about how to tackle disasters before they are entering universities. But in the case of the higher educational institution, there is a lack of standardization in Japanese universities’ in providing disaster education (Emanuel Leleito, et al., 2016). Besides, most of the international students come to study at the university level who have different disaster knowledge and skill levels (Kawasaki, et al., 2018). It is found that a large number of students who have a low level of awareness are very nervous during the disaster and unable to take proper actions and cannot
protect themselves sufficiently during an emergency.

It is very challenging to conduct an earthquake disaster education or training course because it cannot be replicated. It is also hard to involve the students emotionally in the learning process or take them to the real affected sites. The study found that, like many other disciplines, video contents are very popular and essential in disaster education and training and have a greater impact on the learning and retention process as well as increase student’s skills and awareness of disaster. The learning procedure becomes more stimulating, supports self-directed and collaborative learning, and learners get emotionally engaged in the learning process.

2. Research Problem

In Japan, the number of DSS video contents, specially designed for international students is not enough. Moreover, the available contents are usually integrated with several topics and make it a long video. Filtering expected contents, including important inside parts based on students’ attention and retention process and learning progress, is essential in video-based learning. In self-directed learning, such long video content pose some difficulties. Firstly, long videos are combined with several topics or learning objects (LO). If one video has this kind of hierarchal structure, it is difficult for the system to control the video sequences and the student’s watching/learning behaviors. Secondly, defining target parts from the long video consumes time and much concentration of the students (Sagorika & Hasegawa, 2019). Several studies found that students’ concentration drops around 10-15 minutes while watching long videos (Bradbury, 2016). So, segmentation of long videos into meaningful chunks for faster skimming and re-watching is important (Guo, Kim, & Rubin, 2014). Finally, it is hard to select the right video content in the traditional video learning process based on the students’ needs and knowledge levels. It is also challenging to know students’ preferences/attention and retention process inside the video parts, including the duration and repetition of watching. In this situation, there needs a user-responsive video learning support tool that could resolve existing limitations and fulfill the students’ requirements.

3. Objective and Research Questions

Based on the above situation the objective of this research is to design three essential models i) students’ model ii) e-teaching strategy model, and iii) domain model, and finally a conceptual model with the integration of VART for supporting video-based DSS learning on earthquake for international students in Japan. In pursuing the above objectives this research has been formulated following Research Questions (RQs).

RQ1: What type of students’, e-teaching strategy, and domain models are required for video-based DSS training? and,

RQ2: How these models can be integrated with the VART system for enhancing DSS skills??

4. Literature Review

The research explored available literature based on three essential components/models of the proposed VART system. The findings of the reviewed literature are categorized and presented below:

4.1 Characteristics of the International Students

Japanese students have a high level of disaster preparedness knowledge, but International student’s knowledge level is quite low, and learning need is different from Japanese students. Also, there are different levels among international students based on their prior knowledge and experience (Haburi,
Takahashi Sachiko, Miura Emi, 2016), (Emanuel Leleito, et al., 2016). The behavior of international students is different and not satisfactory in the disaster preparation situation. Iwamoto & Ishikawa (2011) found that around 60% of international students never experienced an earthquake in their home country, and 80% of respondents were very worried during the earthquake in Japan. Bustanul, Bisri, & Sakurai (2016) suggested that it is important to know the special needs of international students, understand their risk awareness and preparedness levels to provide inclusive education and training to them. Therefore, the study suggested that the education method should be conducted in a different way for international students (Emanuel Leleito, Kaori Shimasaki, Rumi Watanebe, 2016). The language barrier, cultural differences, lack of knowledge about local disasters and drills, etc. lead them to lack of access to the disaster education resources (Kawasaki et al., 2018), (KONDO Yumi, 2015). They also have a low interest in the existing disaster survival education because often education and training provided on disasters are not suitable based on their need (Nakagawa, 2016). Their special needs are specific, fast, reliable, easily accessible contents with no language barrier tied to relevant knowledge on disaster prevention actions (Xin, Sugiki, & Matsuo, 2017), (Gómez, 2013), (Nakagawa, 2016).

4.2 Characteristics of the DSS Educational/Training Strategy in Japan

In Japan, Nagoya University and Tohoku University started a combined Disaster Risk Reduction Education (DRRE) program for the first time in 2014 to cultivate disaster preparedness skills among the international students. The course provided important teaching and learning experiences on disaster both for the teachers and students in many positive ways. At the same time, combining several methods, for example, face to face, video conferencing, field trips, group projects, and reports were challenging. The study suggested combining the pre-recorded video lectures with video conferencing and sorting out the duplicate contents. The final version of the video contents may be compiled and shared with different universities through the web. Finally, the study seeks a proper model and platform for future DRRE to cover a wide range of international students in providing collaborative education throughout Japanese universities (Emanuel Leleito, et al. 2016).

On the other hand, Shiroshita (2017) suggested that disaster education might be conducted in such a way that it could provide the opportunity of co-learning and sharing the sense of disaster among the learners. The APRU-IRIDES multi-hazards campus safety workshop, 2018 in Sendai, proposed that orientation training to the new students and special training on disaster preparedness to the international students should provide regularly (APRU, 2018). However, from the literature, we could not find any solid teaching strategy for DSS education. On the other hand, we found that the nature of the disaster education/training is mainly single university-based and, in some cases, joint-university collaborative education-based. There needs special disaster training for international students and the repetition of disaster training is also required.

4.3 Characteristics of the Current Content Delivery Method

Japanese universities arrange emergency evacuation drills/training once or twice a year to create emergency awareness among students. Besides, there are text-based instructions on the university webpages on ‘guideline for crisis management’ verbal lectures and e-mails for foreign students on disaster control (JAIST, n.d.), (University, n.d.). But many international students are not fully aware of such drills, and instructions are delivered by unknown language. Besides, the contents on disaster are provided to them are not necessarily specific based on their demand (Nakagawa, 2016). There are also different types of contents such as text-based, verbal lectures, audios, videos, games, simulations, etc. that are available for disaster education and training on different sources. Wahyudin & Hasegawa (2015) developed a 3D role-playing mobile serious game named MAGNITUDE to train inexperienced disaster volunteers to make proper ethical decisions. Hatakeyama, Nagai, & Murota (2016) developed a scenario-based learning support system named Evacuation Scenario Simulator System (ES3) to improve students’ judgment capacity in an emergency. Hiroyuki Mitsuhara et al. (2015) developed a web-based system using ‘Bosai Yattosar’ (BY) to design a game-based evacuation drill (GBED).

Toyoda & Kanegae (2019) established a connection between problem-based learning (PBL) and gaming.
simulation (GS) to provide earthquake evacuation practice and training among university students. However, only game-based content cannot fully meet the DSS learning requirements, and creating a virtual reality (VR) environment for simulation training is expensive and time-consuming to teach a huge number of international students in public universities. Research results show that, among all other content and content delivery methods, inclusive disaster training videos are very convenient and effective and can improve learners’ understanding of disaster education more deeply (Mar et al., 2019). Therefore, students showed high interest when learning is conducted with audiovisual contents (Sejati, Budiningsih, & Pujianto, 2019). But, in the contemporary video learning process, it is hard to select the right video content based on the learner’s knowledge levels, attention, and retention process. Also, defining andfractioning essential parts with meaningful tags from the long video is challenging and time-consuming (Sagorika & Hasegawa, 2019). On the other hand, replicating the natural disasters like earthquake and providing real feelings through conventional contents and content delivery methods is very difficult (Lin et al. (2013).

The literature review from the above three main topics found that there are limited scholarly publications focused on emergency preparedness related to university students, and how disaster education is developed for the newcomer and international students (Tanner & Doberstein, 2015), (Bustanul et al., 2016). A very few researches have been conducted to realize the suitable content and content delivery method for effective disaster education based on students’ special needs (Dufty, 2018). Very limited research was also found on DSS teaching and training strategy in Japanese Universities.

This lack of previous research support factor itself emphasizes the need for disaster survival skill training among the international students to save them from an emergency. The most important finding is among all other contents video content being considered as effective and widely used in disaster survival education and training. Therefore, this research initiates to provide DSS training among international students in the universities using selected and effective video content with the help of VART to assist in the self-directed video-based learning.

5. Research Method

This paper mainly focuses on the ADDIE model's design phase for the development and implementation of the VART system. The ADDIE model includes five important phases analyze, design, development, implementation, and evaluation, which is traditionally used by instructional designers and training developers. First, we analyzed the problems of the international students they face in DSS learning, their demand, and why they need support. Second, we analyzed different teaching strategies as well as content and content delivery methods, especially video content used in DSS learning, and identified the difficulties in the traditional video-based DSS learning. Third, we have defined the system's technical requirements/functions to be developed to resolve the problems. Finally, the research has provided the design architecture of the essential models for VART. The models have discussed details in the following sections.

6. Components of VART

Based on the above discussion, how to create required domain functions to the videos and how to analyze the videos and provide support for the students with the support of VART, these three parts are considered the main functions for this paper. We have explained these primary functions to clarify the design phase of students’ model, domain model, e-teaching strategy model, and relationship with VART with these three models. This discussion part has many similarities with our previous published journal article titled “design of video aided retention tool for the health care professionals (HCPs) in self-directed video-based learning” (Sagorika & Hasegawa, 2020). In this paper, the international students' learning goal is different from the HCPs, and the learning support provided by the VART has some new features with many similarities with the mentioned article.

The goal of this research is to support international students in the video-based disaster survival
skill learning. As mentioned, video contents, especially real-life scenario-based, situational and demonstration video has the potential that students can learn DSS from it. Nevertheless, the videos are long, and the relationship is not clear in different videos, and the navigation is poor. So, the proposed system provides the function to track the student’s activities and provide the navigation function to improve the retention process for learning. To understand the proposed design models, the retention process is fundamental in DSS learning. Because retention realizes the skill of learning from the videos. Retention, mini-tests, and similar activities can fill the gap between the knowing concept and be able to act. For the first time watching students get to know the concept, but by several times watching and answering mini-tests, they move to act which will ultimately help them to do the right action in case of a disaster situation. So, retention is a process of knowing the concept to move to an act of being able to act. Based on this, we designed these retention-based models. The learners' specific goal is to achieve the skills or act by watching the videos several times effectively. Moreover, the specific skills to be learned are disaster survival skills, i.e., preparedness skills, decision-making skills, and so on based on different video contents.

6.1 Students’ Model

In the e-learning environment, some commonly used student models are overlay models, the stereotypical model, and the perturbation model, and so on to design student models. The overlay model represents a student’s problem-solving approach in a particular domain on a modular basis. Brusilovsky & Millán (2007) stated that the overlay model represents students’ model as a subset of the domain/expert knowledge. Shyamala et al. (2011) described that based on the domain model, the overlay learners’ model consists of the value of an assessment module of a particular concept. This value may be binary (0 – does not know or 1 - know) and a categorical variable (low, medium, high). Based on international students’ learning requirements, this research designed a students' model following overlay approaches. Figure 1 illustrates the DSS students’ model of international students.

![Figure 1. Students’ Model](image1)

![Figure 2. Retention of a single viewer](image2)

International students have different knowledge and skill levels, goals, approaches, preferences, understanding, etc. Based on the preference, students may watch some videos from the domain as retention and system get the student’s model based on watching duration, repetition, most watching parts or comments, etc. This is considered as student’s behavior on the Learning Objects (LO). The students’ model basically indicates the relationship between the domain model and the student’s activities. In figure 1, there are five learning objects on the upper table at the top right side, and how students watch these objects is a retention process. Figure 2 is a visual example of a single students’ retention history on a 15 minutes 27-second video. The student watched the video twice. The blue arrows on the top indicate the student's most watching parts, repetition of watching and duration of watching, and the arrow at the bottom level shows the learner's detail watching fluctuation history. This process could be applicable for a certain student or other students or groups of students; such as, ‘the watching duration’. Student 1 may watch LO1 9 minutes, LO2 0 mins, LO3, 6 mins, LO4, 5 minutes, or vise versa. On the other hand, students 2 may watch in a different way. Based on students’ preference and retention, the system can recommend different videos to student 1 and student 2 subsequently.

Besides, the level of learning outcome is determined on whether students watch a particular video or not. If a student does not watch a certain video, VART will identify him/her as a beginner.
Similarly, if any student watches the video, the VART system will calculate the total number of watching videos, watching duration, repetition, and important parts to identify as a mid-level or advanced level student.

6.2 Domain Model

In the proposed domain model, different types of DSS courses could be designed and structured based on international students' learning requirements. The traditional video domains mainly focus on video content management and control including the organization of subjects and displaying the contents sequentially one after another. But, in the proposed domain model, it includes the traditional features with extended features of VART, which has made the video content more specific and students' centered. These features include the control inside the video, provide adaptation using automatic indexes to identify important parts with meaning, and track, analyze, filter, and recommend features based on student's requirements. Moreover, we use the H5P interactive content plugin integrated with the Moodle to create, modify, rich, and interactive video contents in the domain. This plugin also adds interactions and mini-tests to the videos to realize students’ retention outcomes or skill learning outcomes.

However, the VART also analyzes and identifies essential parts inside each video, puts automatic indexes or tags, and represents the video with a brief description. As a result, students can easily pick up the most important part first saving their time and concentration. There are some approaches to put automatic indexes inside the video. For example, VART can apply the Natural Language Processing (NLP) to automatically detect the rough contents to get keywords from the slide data, title, and subtitle of the video, and create some necessary meta-data for each video part. Another function is if students make comments for the video, the system can detect such text data as a part of the indexing to provide the meaning of that content. Here, we have designed a sample domain or content model based on the main course DSS on earthquake, since this is a very important topic for all the international students. In our proposed system, VART relates to the domain model through Moodle LMS. Figure 3 shows the VART connection with the domain hierarchy. The bottom part of figure 3 shows how it displays the short description of the video and how it analyzes and filters important parts in video content.

Figure 3 also illustrates that, in the domain model, there may have different domain hierarchy based on different subjects or topics. But, in the case of self-directed video-based learning, students should have enough flexibility in their learning. They can choose different topics and sub-topics which are known as Learning Objects (LO) from different modules as they prefer. For example, any student can learn the ‘nature of earthquake’ and ‘preparedness’ from module 1 and then move to any module and any topic they like. In the domain hierarchy, contents are inter-related with module to module and LO to LO. The blue arrows show the connection among the module to module, and the green arrows show the connection among LO to LO.

6.3 E-teaching Strategy Model

In the proposed system, the e-teaching strategy technique is determined based on the combination of content structure and students’ preferences data from the domain model and the students’ model. The
VART system will combine students' watching history data, including content preferences, watching duration, repetition, most important or most watching parts, and other information from the students’ model and domain model and decide the proper recommendation. For example, in content structure, some contents are considered key content or fundamental concepts to be learned first. In figure 3, in the domain model, for instance, learning object 3 has many links to other LOs. Usually, this kind of learning object is considered as the pre-requisite object. So, if some students did not learn the LO 3, 6, 7, 8 they should learn from the LO3 from the content structure. The DSS contents are selected and limited. So, the system can recommend the basic concepts to be learned first. Another strategy is that if someone learns the LO3, following recommended content, they should go to LO 6, 7, or 8. Of course, another idea is LO4, and LO4 has connections with LO8 and LO11. If LO8 is already watched, after learning LO4, they can move to LO11. This kind of relationship is important, with the number of the students watched the video. It may depend on the students’ preferences too. If students want to pick-up the important topic, in that case, most hunted parts or most watching parts are okay. But, if they want to learn the concept based on the domain hierarchy, they should follow the domain structure. In this way, the system can also create some teaching strategies from the domain model. So, the system can propose different strategies combining different parameters; for example, content structure and students’ preferences, students’ preference, and most watching part, students’ preference, and repetition, or less watching and no watching, etc. The e-teaching strategy model of VART is illustrated in figure 4.

In the e-teaching strategy model, the system will provide mainly five approaches to the recommendation. Figure 4 shows (i) it will track content structure and students’ preferences (ii) most watching parts, (iii) most watching students, and (iv) less watching student’s data. Based on the students' different attributes and attention approaches, it will filter or recommend and deliver different content to the different students depending on their levels. The fifth approach is to use other students’ watching history. If a similar level of other students watches a certain part in the video, the system will recommend it. For example, everyone watches LO3, but a certain beginner did not watch LO3, in that case, LO3 should be recommended to that student. If there is no other student's data in some LOs, the system can recommend based on student's preference data. Another pattern is that if some students are advanced learners and have enough knowledge of earthquake survival, they can skip the earthquake awareness and preparedness basic contents even if other students watched those parts.

6.4 Integrated VART Function Model

The VART model has a three layers structure, including the students’ model, e-teaching strategy model, and domain model. Figure 5 demonstrates the integration of VART functions with different models on the LMS. With the support of VART, the domain model presents the content hierarchy, essential parts with the meaning of the videos, and students watch and learn from the video as retention and system get the students’ model based on the duration or repetition or comments or other information. This is considered as the students’ behavior on the learning objects. The VART also helps the e-teaching strategy model to receive and combine data from the domain model and the students’ model and know the student's attention and retention process. Accordingly, it proposes strategies, using the parameters on students’ models and learning objects. So, students’ model and e-teaching strategy models assist students based on their learning process and progress in the domain and provide adaptation in the self-directed video-based learning system. Thus, the three models are the essential computational models inside the VART system. The learning process from LO to the students is retention, and the system filters or recommend the contents add attention. Therefore, these are the major VART functions with different models which are the main part of the LMS.
7. Functions of VART

7.1 Control the videos

The VART system combines the domain hierarchy information, notable attention, and retention parts, and the learning history of the previous learners and picks up the important video sequence and provides it to the students as a brief description. If students feel the video is useful, they can watch it from the actual learning resources. In the disaster education field, often many topics are included in a single long video. If one video includes all most all the important content, students should learn all of them. So, it is needed to fill the empty knowledge of the students from all the topics. Besides, the content order should be organized by the system to keep interested or motivated or consider the more important skills for the students to be learned first. In this case, the VART organizes and split one video into some specific topics and make a hierarchy and control the learning. Moreover, if enough content is not found, the system can recommend different video sources or webpages.

![Figure 5. Integrated VART Function Model](image1)

![Figure 6. Overview of the VART Model](image2)

7.2 Analyze video contents

Traditional video service platforms, including YouTube, TED, DTube, Dailymotion, Google Video, etc. provide a specific video's history. But, in DSS learning, only such kind of general history data is not enough. Students need to know both about the video and the essential parts inside the video. Besides, students have a variety of learning behaviors, knowledge, and skill levels. In this case, the proposed VART can detect the number of watching and duration of the watching history of the specific part of the video. For example, the part of the watching history from 1 minute to 6 minutes, etc. Only such history data might be a popular part, but if the system can add meaningful indexes or metadata for inside video contents, students can find each part of the video's meaning. For example, this popular part includes this topic, i.e., from 1-4 minutes nature of earthquake, 4-10 minutes preparedness, 10-16 minutes immediate actions, etc. The VART system can put such indexes for videos, not video files, but tags for each timeline inside videos, students can easily understand the topics included in the video and which parts are more important for them to learn first based on their knowledge levels.

In figure 6, we have represented the main elements and final output of the VART system. VART uses video data set and students' watching history from the domain model and student's model as input data. After that, it tracks and analyzes videos based on the student’s attention and retention process. In this figure, attention indicates student’s preferred topics or expected parts inside the videos, and retention indicates the remembering process or learning process of a student. However, after analyzing the input data it filters, recommends, and delivers specific content to the students considering different strategies. The detailed functions are described in the components of the VART section.

7.3 Track watching behaviors

In the proposed platform, the VART will first detect each student's ID and track what type of contents
they seek; this is called attention. At the same time, it will follow the students watching duration and repetition of watching, their comments, their difficulties, or intentions, which is considered as retention or remembering process. Based on such a learning process and progress history data, the system could analyze, filter, and change how to show the video. Thus, the system can recommend which part is essential using the attention and retention process and watching history data and can filter contents based on students’ preferences, learning behavior, and their competency level.

8. Originality

The approach of providing DSS training using selected video contents and fragmentation of the long videos into meaningful chunks in small, highly focused materials has similarities to microlearning. Microlearning is often referred to as a bite-sized method and provides the opportunity for the students to absorb the long volume contents in a digestible manner (Giurgiu, 2017). However, small contents are easy to understand, but the complicated content or concept is difficult to understand in microlearning. From the microlearning point of view, we have added function to navigate or to make retention for the important parts of the videos, which is different. In this research, tracking students’ video watching behaviors inside video parts, and delivering the contents based on their attention and retention process is different. The form of the basic content is similar to the microlearning, but the support method is different. The main algorithm of this research is to provide support in the retention process of the students to understand the difficulties and unfamiliar concepts in the video content.

9. Conclusion

For effective DSS training, contents should be specific and appropriate for the international students and need to be represented based on their different knowledge and skill levels in a modest and convincing manner to feel the enthusiasm to learn from it. In addition, tracking learner’s learning behavior, providing support based on their retention process, know their learning outcomes, and repetition of the training is also required. Some existing research discussed the lack of specific content, learning environment, socio-cultural, and language barriers for international students. However, nowadays we also have many effective tools i.e. smartphones, smart glasses (Kawai, Mitsuhara, & Shishibori, 2015), smartphone-based binocular opaque HMD (H Mitsuhara, Iguchi, & Shishibori, 2017), etc., and other smart devices. But we do not know how to use it instantly and effectively in the emergency disaster situation. In such a case, a video-based DSS training method could be effective, convenient, cost-effective, and can cover a large number of students to provide training in public universities. The proposed VART system might help overcome the existing problems in video-based DSS learning and help students acquire necessary DSS skills in the self-directed learning manner. In addition, the VART models and systems are flexible enough to apply in other disciplines of video-based teaching and learning environment. In that case, based on the different domains, some features might be changed or might need to add new features with the existing common features.

As the ongoing work, we are currently working on the development phase of the proposed system, and soon, we will implement the new system and assess the learning outcomes among the international students. In the evaluation phase, we will compare the different settings about the learning process. So, we will gather the number of participants, divide the participants into two or more groups, and assign different conditions. For example, we will apply the VART learning support tool while watching the video content. Second time there will have no support. Students will watch the video using the Moodle and we will compare the improvement of skills for survival. First, we will examine the initial skill for survival as a pre-test and after learning the video with support and without support, we will conduct the post-test to compare how they have improved in each category. In addition, we may assign one single student in two different conditions. For example, if we provide two different videos, the first one is for decision-making skills with VART support, and the second one is for survival skills without VART support. In this case, the skills to be learned are different. It depends on the target video
content, but we can also compare such kind of different settings to know the effectiveness of the learning topics used in the DSS training.

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Academic Support for All Students Based on Reasonable Accommodations in Emergency Situations Using AI Chatbots

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Abstract: Shikoku University in Japan has implemented a plan to improve academic support for all students, especially those who need reasonable accommodations for their disabilities, so that they can spend their time at the university in a meaningful way and with peace of mind. In this context, we conducted a questionnaire survey to determine the best way to communicate with the students who are provided with reasonable accommodations to support their studies and to take classes remotely during the COVID-19 pandemic. Almost all of the respondents requested an easy way to communicate with the faculty members via the LINE Social Networking Service (SNS). We propose the use of an AI chatbot using LINE as a learning support plan for emergency situations such as COVID-19 and disasters.

Keywords: safety education, reasonable accommodations, academic support, AI chatbot, SNS

1. Introduction

The university’s response to the reasonable accommodations initiative began in 2016 when the Disability Discrimination Elimination Law was introduced, and comprises a detailed consideration plan for students wishing to take part. As a complement to existing learning support, the initiative improved the learning environment for all students, not just those who have been granted reasonable accommodations, and this, in turn, has supported the effectiveness of further university education.

Considerations for each disability in reasonable accommodation are as follows.

- Physical disability: cerebral palsy, muscular dystrophy, etc.
  - Consideration for classroom mobility and use of dedicated computers and tablets
- Hearing disability: Deaf.
  - Consideration of seating positions where the mouth is visible and methods of communication.
- Visual impairment: blindness, low vision, etc.
  - Consideration for Classroom Movement and Reading.
- Developmental disabilities: autism spectrum disorder, attention deficit/hyperactivity disorder, etc.
  - Effective use of PCs and tablets, avoidance of ambiguous expressions, etc.
- Mental disorder: depression, schizophrenia, etc.
  - Consideration for seat assignments, late arrivals and departures, and absences.
- Weakness, epilepsy, etc.
  - Treatment of absences due to hospital visits, etc.

As part of the promotion of mental health and the prevention of mental health problems, Shikoku University conducts a survey, through questionnaires, of the concerns of all students in their first year. While students sometimes apply for accommodations based on this questionnaire, it has also been reported that students expressing needs beyond the norms of the questionnaire can have problems with absenteeism from classes and motivation to study, and this is typically due to mental health issues. Students with depression in particular, are often re-interviewed alongside their parents, and, as a result, such students sometimes apply for reasonable accommodations. A common problem in higher
education institutions worldwide is that students with mental health disorders, such as depression and autism spectrum disorder, tend not to voluntarily apply for accommodations. For students with such mental health disorders and for students in the ‘grey area’, who show symptoms that do not meet diagnostic criteria despite having characteristics of developmental and mental disorders, anxiety about their new environment is thought to be a factor in absenteeism, and some students may even be forced to leave school as a result.

Figure 1 shows the flow of correspondence between students who need academic support, especially reasonable accommodations, and related faculty members, from the time the students enter university to graduation. This correspondence can be broadly classified into three types.

(a) All first-year students are surveyed about their concerns, and depending on the circumstances of each new student, a tutor will consult with them and, if necessary, ask them to apply for reasonable accommodations.

(b) The application procedure for the provision of reasonable accommodations: application, interview, review/approval, planning, agreement/signature, start of accommodations and a series of application procedures.

(c) Tutors are available to all students for consultation and inquiries regarding daily university life and academic support. Tutors also provide support to students who receive reasonable accommodations, such as consultation on accommodations, re-evaluation and re-examination, until graduation.

![Figure 1: The general flow of learning support and reasonable accommodations from admission to graduation.](image-url)
However, since there may be a limit to the amount of learning support that the university can provide, a comprehensive accommodations plan that includes both the university and the student’s home is essential. In addition, about 70% of all students at Shikoku University are female (FY2019), and it has been reported that it is important for women to understand and support their parents at home. Thus, reasonable accommodations need to be understood and supported by the university, the student and the student’s family.

In terms of web accessibility, the user interface (UI) and functions of Shikoku University’s home page and the portal site used by students are not much different to those of other universities in Japan. In fact, web accessibility and the provision of learning support services that utilise websites is generally poor in universities worldwide.

With this in mind, a questionnaire survey entitled ‘About portal site for consideration only’ was conducted with five students from the department who had already been provided with reasonable accommodations regarding the current accessibility of the homepage and the portal site of Shikoku University.

2. Results of the questionnaire on the portal site project

2.1 Results of the Questionnaire Survey

In the questionnaire, we asked 11 questions anonymously from a web-only questionnaire page. All respondents were female, and there were five degrees of disability in total: three students had mental health disorders, one had a mental and hearing disorder and one had deafness. In line with previous research, the proportion of women with mental health disorders was much higher than that of men. Table 1 shows the questions and responses.
<table>
<thead>
<tr>
<th>Questions</th>
<th>Student A</th>
<th>Student B</th>
<th>Student C</th>
<th>Student D</th>
<th>Student E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1: What is your preferred way to contact university faculty and staff members?</td>
<td>Portal site, e-mail</td>
<td>e-mail</td>
<td>SNS such as LINE, e-mail</td>
<td>SNS such as LINE, e-mail</td>
<td>SNS such as LINE, e-mail</td>
</tr>
<tr>
<td>Q2: Do you need to ask questions about university life, such as about lectures, on the site?</td>
<td>Necessary</td>
<td>Necessary</td>
<td>Necessary</td>
<td>Necessary</td>
<td>Necessary</td>
</tr>
<tr>
<td>Q3: On the site, do you want to create new applications, make changes or suspend reasonable accommodations?</td>
<td>Necessary</td>
<td>Unnecessary</td>
<td>Necessary</td>
<td>Necessary</td>
<td>Necessary</td>
</tr>
<tr>
<td>Q4: Do you wish to check the contents of the current accommodations plan on the site?</td>
<td>Necessary</td>
<td>Unnecessary</td>
<td>Necessary</td>
<td>Necessary</td>
<td>Necessary</td>
</tr>
<tr>
<td>Q5: Do you wish to check today’s lecture schedule via a listing on the site?</td>
<td>Don’t know</td>
<td>Necessary</td>
<td>Necessary</td>
<td>Necessary</td>
<td>Necessary</td>
</tr>
<tr>
<td>Q6: Do you wish to pre-book a classroom seat on the site?</td>
<td>Necessary</td>
<td>Unnecessary</td>
<td>Don’t know</td>
<td>Don’t know</td>
<td>Necessary</td>
</tr>
<tr>
<td>Q7: When you cannot attend a class, would you like to access it online?</td>
<td>Necessary</td>
<td>Necessary</td>
<td>Don’t know</td>
<td>Necessary</td>
<td>Don’t know</td>
</tr>
<tr>
<td>Question</td>
<td>Necessary</td>
<td>Necessary</td>
<td>Necessary</td>
<td>Necessary</td>
<td>Necessary</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>-----------</td>
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<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>Q8: When you take a break from a lecture, do you wish to check alternative assignments on the site and upload submissions?</td>
<td>Necessary</td>
<td>Necessary</td>
<td>Necessary</td>
<td>Necessary</td>
<td>Necessary</td>
</tr>
<tr>
<td>Q9: Do you have any other requests related to accommodations that should be added?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Q10: If you were to use such a site, are there any concerns that you might have about it?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Q11: What do you think is the most important support to allow you to graduate?</td>
<td>None</td>
<td>An environment where it is easy to consult for credits, courses and absences</td>
<td>None</td>
<td>Like other students, I just want them to support me</td>
<td>Support for reasonable accommodations until graduation and support for job hunting</td>
</tr>
</tbody>
</table>
2.2 Analysis of Results

Concerning the students’ preferred method of contacting the university in Q1, all of the respondents answered that it would be convenient for them to use existing, familiar communication methods such as e-mail and Social Networking Service (SNS), and convenience was considered the most important factor. Regarding contact via the university portal site, although some students answered that they needed this, the current system allows university faculty members to contact students, but the reverse is not possible.

Q2 to Q8 relate to the type of system required for the web application planned in the future. Of these ‘general questions relating to issues such as lectures and missed lectures’, the students mainly responded that these functions were needed, and that a counselling service in a dedicated portal site was essential. In addition, in response to Q5 and Q7 (confirming class schedules on the day and online classes in the case of being absent), most of the students answered that this was necessary. For Q3, Q4 and Q6, more students said that these facilities (application for or modification to an accommodation plan, checking the current accommodation plan and booking a seat, respectively) were necessary than said they were not.

One of the responses to Q9 also anonymous consultation, so it would be advisable to set up a separate ‘Anonymous consultation desk’ for asking questions about university life.

None of the students reported problems with the site Q10, but we would still like to consider any potential concerns in advance and devise solutions. In all circumstances, maximum privacy should be assured.

For Q11, most students said that ‘consultation and support’ was the most important requirement for graduation. Thus, communication with students is the primary objective of the dedicated portal site plan, and this must be reflected in the design.

2.3 The Role of Tutors, Based on the Questionnaire Results

Most first-year students have few friends at first and are not familiar with the university environment or with teachers’ names, so most experience a certain amount of anxiety in the initial months of university. During these early days, it is difficult to exchange information using SNS for the above reasons, so faculty members often simply ask students questions such as ‘How are you feeling?’ and ‘Do you have any concerns?’. In this way, they attempt to relieve the students’ stress.

Students enrolled in a class may also be asked to help as tutor support. We plan to train such students as peer tutors and offer a financial reward for each instance of support given. In this way, it will be possible to provide substantial accommodations by obtaining the cooperation of students as well as faculty members. In the future, a questionnaire survey on reasonable accommodations will be conducted among faculty and staff who provide them, and, based on the results, we will continue to offer information and practical training on disability awareness to all faculty and staff.

2.4 Responding to students in an emergency situation

The role of tutors has increased in recent years as part of the measures to prevent the spread of the COVID-19 pandemic. Normally, we can provide face-to-face support, but in the current pandemic, we tend to support students by e-mail and SNS. Under these circumstances, we believe that we can provide more useful support for students by incorporating AI chatbots into SNS and other services.

3. Plan for Conversational Chatbot Using SNS

3.1 Benefits of Conversational Chatbots
Chatbots are beginning to be used in educational institutions as part of academic support services and are being discussed in international conferences as part of research on innovative computing and communication. However, the problem is that professional research on academic support services, including reasonable accommodations, is an issue for future research.

Most of the students who completed the survey expressed a desire to use SNS to contact faculty and staff. A number of researchers have noted the utility of communication using such web applications, and we would like to actively promote their use. Conversational chatbots can be used to great effect to address the time demands involved in contacting large numbers of students. In particular, chatbots are considered the best tool for gathering information about students’ current situations, because they can establish a more friendly and empathetic relationship than traditional point-and-click interfaces.

3.2 AI Chatbot Planning

Chatbots do not need to replace the human role nor completely mimic human conversations, as their purpose is to help people, facilitate work and allow the use of language to interact with computers. However, care must be exercised to avoid emotional communication that may cause irritation or misunderstanding. Therefore, avatar images should be displayed as an additional method of emotional expression in students’ social media, and these will act as an incentive to continue using the chatbots.

We therefore divided web accessibility into three modules, as shown in Figure 2.

(a) All new students are targeted, and the AI chatbot is used to provide academic support, such as questionnaires and consultations, with a focus on anonymity. We emphasise the anonymity of the conversation function, which allows anyone to ask questions and discuss freely without the need for an account.

(b) Students who wish to receive reasonable accommodations can receive support from the start of the application process to the provision of accommodations using a Social Networking Service (SNS), based on an AI chatbot. To receive this support, an SNS account is required to identify the individual.

(c) All students are provided with an AI chatbot to support them in their study, such as daily consultations. For this each student is required to have a social network account, and while we value privacy, we also emphasise the importance of facilitating daily conversations with tutors and others when necessary.

Figure 2: Three modules and the roles required for web accessibility.

Web accessibility must not only consolidate necessary functions and be performed based on optimal policies and security, but also facilitate the natural language understanding and sentiment analysis necessary to produce a response. We believe that better web accessibility can be realised by
analysing changes in the number of student users, the correct answer rate, changes in the number of conversations and so one. This information can then be used to make future changes.

The detailed functions and features of each module will now be explained with reference to Figure 3.

(a) The first step is to offer a web accessibility site that is open to all university students, with its main feature being that anyone can consult anonymously. The avatar of the robot is always displayed with the words, ‘This is a chatbot for anonymous questions and consultation,’ so that even students who are visiting for the first time will be encouraged to participate. A button with a label such as ‘Comment to your teacher’, which allows you to consult directly with the teacher for a solution, is also provided at the bottom of the screen so students can be guided to the next step and receive a more detailed response. Here, it is important to determine extent to which each student needs reasonable accommodations.

(b) The next step is for students to log in to their SNS account (LINE) to enable more detailed procedures. The next steps can then take place application for accommodations, the appointment for the interview, notification of examination/approval, plan guidance, agreement/signature, notification of the start of accommodations provision and a series of application procedures. However, the plan can also be changed at this stage, even for students who have already received accommodations.

(c) As a final step, a student-only SNS is made available for students who have already received accommodations, including daily questions and counselling based on the accommodations plan, such as alternative tasks when absent due to poor physical health. The teachers in charge will guide the staff in leading more specific tasks. In addition, faculty staff can send out information and conduct questionnaires, which can then be used for various communication with students.

Figure 3: UI design of the chatbot system using SNS.
4. Conclusion

Although this study focuses on students with disabilities, covering all students would help them to avoid dropping out of school or taking a leave of absence. The extent to which AI chatbots can determine whether accommodations are necessary depends on the responses to the chatbot and the content of the scenario, and we believe that the construction of an appropriate and rich database is essential. Therefore, Shikoku University plans to obtain the necessary data from a questionnaire survey of faculty and staff, create a database of the data, and improve it through practical experiments so that it can be used more effectively.

Since February 2020, as part of the measures to prevent the spread of COVID-19, we have been working through a trial-and-error approach to deal with the issue of remote learning. However, as all students not just those who are provided with accommodations have more opportunities to study at home and places other than the university, it has become more difficult for faculty members to understand the current situations of the students. It is therefore necessary to consider the study of relevant ideologies as possible countermeasures for students at risk of suicide and self-harm due to the unprecedented environment and to apply the results of that analysis to this study.

Acknowledgement

We wish to express our sincerest thanks to Shikoku University for their cooperation with this study.

References


Make it Fun: The Application of Gamification in Earthquake Education for Foreigners

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Abstract: In this paper, we explore the application of gamification in earthquake education. Earthquakes occur frequently in Japan, so earthquake education is essential for foreigners who live in or intend to visit Japan. However, the earthquake education is neither compulsory for foreigners, nor is it engaging somewhat. To make the earthquake education more attractive, gamification is employed. An ICT-based system, including gamification thinking, is developed to improve foreigners’ participation in the earthquake education.

Keywords: Earthquake education, foreigners, gamification, ICT-based earthquake education system

1. Introduction

Japan has frequent earthquakes every year. However, benefiting from systematic earthquake education, the casualties of earthquake and ensuing tsunami are relatively low in Japan. However, earthquake education in many countries is not satisfactory, which makes people lack necessary earthquake knowledge and survival skills. Or some countries have few earthquakes happening, and people have not experienced earthquakes, so they have no earthquake awareness. These foreigners may fail to survive the earthquake if they were in Japan. Therefore, earthquake education is extremely important and indispensable for these foreigners intending to visit Japan.

Taking account of the shocking destructiveness of strong earthquake and the possible ensuing tsunami, as well as the unsatisfactory situation of foreigners’ earthquake education, our research work concentrates on foreigners’ earthquake education, helping those foreigners who lack earthquake education but plan to go to Japan.

Our research work includes two phases according to the timeline that foreigners enter. The first one is preparation phase. In this phase, foreigners start their earthquake education in their own countries. They may make preparation in advance for their upcoming trip to Japan, building earthquake awareness and learning some earthquake knowledge by using our system. The second one is practical phase, which means learning in Japan. In this phase, foreigners will learn more earthquake knowledge and some practical evacuation skills. For example, foreigners should know the shelters situation nearby their home, so they can arrive at the suitable ones as fast as possible in case of earthquakes. They also need to know what emergent items they should prepare in advance.

At present, our research work is in the first phase, i.e. preparation phase. Gamification is introduced into our system, which makes the somewhat boring earthquake education more engaging to improve foreigners’ participation.

The remainder of the paper is organized as three sections. The second section is brief introduction of gamification. The third section is the introduction of the ICT-based system, as well as the gamification applied in the system. The fourth section is the summary and future work.

2. Gamification: Make it more attracting?
2.1 Definition and application

In the GDC (Game Developer Conference) in 2011, gamification, as a new topic even without definition, was proposed and discussed its pros and cons. Some researchers and game makers harbored opposing views towards this term, but this did not hinder its rapid development. Gamification is defined as: the use of game design elements in non-game contexts (Deterding et al., 2011); the use of game elements and game-design techniques in non-game contexts (Werbach & Hunter, 2012). The definition currently has been reached a consensus and admitted by the majority of researchers.

The definition contains three key points: design elements, game mechanism, non-game context. In brief, gamification is learning from game. Kavin Werbach also said in his online open course at the University of Pennsylvania: Gamification is about learning from games, not just in the sense of learning about the games themselves but understanding what makes the games successful. Understanding what makes the games engaging. Understanding what games can do, why games have power. And then taking some of those techniques, and thoughtfully applying them to other situations which are not themselves games (Kavin Werbach).

Gamification is currently a hot spot and is being widely used in various fields, such as the Internet, medical/health, education, finance etc. (Cudney et al., 2015; Robson et al., 2016; Yang et al., 2017; Hiroyuki & Masami, 2017). Gamification may affect the users’ psychological tendency, thereby increasing users' enthusiasm and participation, improving the users’ experience. In short, gamification makes some 'boring' tasks more interesting, thus attract more users to complete them.

In educational field, gamification has also been playing a role (Hanus & Fox, 2015; Roy & Zaman, 2018; Yildirim, 2017; Tsay et al., 2018). Many researches and experiments have been done to prove gamification as an effective method in increasing engagement as well as learning motivation. By introducing game design elements and well-designed game mechanisms, traditional classrooms are becoming livelier and more attractive, making learning more interesting and easier, and most students' enthusiasm and participation can be significantly improved.

Our system introduces gamification to earthquake education for foreigners because although earthquake education is important in Japan, it is not compulsory for foreigners. Our research and system consider the characteristics of earthquake education and the ICT system, as well as our research objects. Besides the widely used game elements in traditional classrooms, like PBL (Points, Badges, Leaderboards), well-designed gamification mechanisms and some new game elements applicable to ICT system are introduced into our system.

2.2 General gamification taxonomies and elements

Currently, the most commonly used game elements are up to dozens. In general, gamification taxonomies vary according to the different perspectives or fields applied in. For example, table 1 shows one taxonomy. In educational field, some researchers classify these common elements into five dimensions, performance, ecological, social, personal, and fictional (Toda et al., 2019).

<table>
<thead>
<tr>
<th>Table 1. A gamification taxonomy and common game elements</th>
<th>Tutorials, signposting, loss aversion, progress &amp; feedback, theme, story, flow, curiosity, time pressure, scarcity, strategy, consequences, investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schedules</td>
<td>Random rewards, fixed reward schedule, time dependent rewards</td>
</tr>
<tr>
<td>Socialiser</td>
<td>Guilds &amp; teams, social network, social status, social discovery, social pressure, competition</td>
</tr>
<tr>
<td>Free spirit</td>
<td>Exploration, branching choices, Easter eggs, unlockable &amp; rare content, creativity tools, customization</td>
</tr>
<tr>
<td>Achiever</td>
<td>Challenges, certificates, learning &amp; new skills, quests, levels, boss battles</td>
</tr>
<tr>
<td>Philanthropists</td>
<td>Meaning &amp; purpose, care-taking, access, collect &amp; trade, gifting &amp; sharing, sharing knowledge</td>
</tr>
<tr>
<td>Disruptor</td>
<td>Innovation platform, voting &amp; voice, development tools, anonymity, light touch, anarchy</td>
</tr>
<tr>
<td>Player</td>
<td>Points, physical rewards, leaderboards, badges, virtual economy, lottery &amp; game of chance</td>
</tr>
</tbody>
</table>

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In our system, the game design elements being used or going to be used include badges, points, leaderboards, mystery box, exploration, time-limited missions, Easter eggs, information sharing, etc. These elements are classified as reward mechanism, competition mechanism, free spirit mechanism, achievement mechanism, and challenge mechanism. Some mechanisms are overlap in elements, e.g., Easter eggs belong to free spirit mechanism, meanwhile, users get some rewards (reward mechanism) from the eggs. Table 2 shows game elements and mechanisms applied in our system.

<table>
<thead>
<tr>
<th>Reward mechanism</th>
<th>Points, badges, mystery box</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competition mechanism</td>
<td>Leaderboards</td>
</tr>
<tr>
<td>Free spirit mechanism</td>
<td>Exploration, Easter eggs</td>
</tr>
<tr>
<td>Challenge mechanism</td>
<td>Time-limited missions</td>
</tr>
<tr>
<td>Achievement mechanism</td>
<td>Information sharing</td>
</tr>
</tbody>
</table>

In the current phase, i.e. preparation phase, the system includes some basic game elements, like point, badge, leaderboard, mystery box. In the second phase, i.e. practical phase, some new game elements, and game design mechanisms will be employed in the earthquake education system. The interpretation of how the gamification works in our system is given in section 3.

3. Earthquake education system applying gamification

The system includes two parts: server side and client side. Figure 1 illustrates the architecture of the system.

![System Architecture](image)

3.1 Server side

The server is designed and developed based on the Springboot framework and implemented using Java development language. Currently, it supports up to 200 concurrent accesses in this version. The server requests earthquake information from JMA (Japan Meteorological Agency) in the pulling type, accessing the designated URL once a minute to fetch the XML format file. The server parses the XML file to check if new earthquake information is available. If there are some new earthquake information URLs, the server accesses the URLs respectively, and abstracts the earthquake information.
The server supports the WebSocket protocol. WebSocket enables the Client side to get new earthquake information in the push type. The client side makes a subscription to the server, and the server will push the new earthquake information to the client side, which reduces the client's polling times and http abuse.

In addition, the server provides some auxiliary functions, such as storing the user's personal profile, settings, and learning records, if this user is a registered user. The server will push remote notification when our client side is out of connection.

3.2 Client side

The client side is in the form of a cross-platform application that supports iOS and Android operating systems. The App is developed by Flutter toolkit and Dart development language. The App fetches earthquake information from the server through subscription, and then displays them according to seismic magnitude and epicenter.

Gamification is a complement when the learning motivation is not sufficient. All game elements are related to intrinsic or extrinsic motivation (Ryan & Deci, 2000; Huang & Hew 2018). In this paper, besides the basic game elements PBL (points, badges, leaderboards), mystery box was employed. Points and badges belong to reward mechanism and relate to extrinsic motivation. Mystery box belongs to reward mechanism, but it is related to intrinsic motivation. Leaderboards belong to competition mechanism and relates to intrinsic motivation.

In the early stage of earthquake education, extrinsic motivation is thought to quickly attract more users. As mentioned above, earthquake education itself is a relatively boring thing, nor a compulsory course, which means extrinsic motivation may be an effective way to attract users' attention. An engaging beginning may motivate more foreigners to access the earthquake education. Intrinsic motivation is an important factor to maintain users' long-term engagement. In the follow-up work, some game elements and game mechanisms integrating intrinsic motivation and extrinsic motivation will be employed in our system.

The App supports various learning methods and materials. It enables users to learn anytime and anywhere. It provides learning materials including URL, video, text, picture, etc. Users can get rewards according to their study. The figure 2. shows some snapshots related to learning in the App.

![Figure 2. Snapshots of learning in App](image)
In details, the rules of applying game elements in the system are that the more users use the system, the more points they obtain, the larger number and more types of badges they gain, as a result their rank is higher. Users may get a mystery box containing a random number of points. The specific rules are as follows:

1) awaking the app gets one point, no more than one point per day.
2) browsing the pushing-message add one point, no more than 3 points per day.
3) reading learning materials for at least five minutes can get one point, at most 3 points per day.
4) completing a quiz can get one point, at most one point per day.
5) a high correctness over 90% will gain an extra point.
6) using the app for at least five days in a week will win a bee-badge for hard working.
7) full marks in test gains a clever monkey-badge.
8) each week, according to the number of badges, the first place on the leaderboard will gain the title of master, and a mystery box including a random number of points between 1 to 5.
9) users may get a mystery box containing points between 1 to 5 during using the system, and the possibility is calculated based on a random number, and users' overall performance is considered too, as shown in the third snapshot in figure 3.

The snapshots related to gamification are shown in figure 3.

4. Summary and future work

In brief, the popularity of foreigners' earthquake education is unsatisfactory. Lacking earthquake awareness results in low engagement in earthquake education, which may be a negative factor for foreigners intending to Japan. To improve this situation, gamification is adopted in our earthquake education system. By using some game elements and mechanisms, gamification makes the earthquake education more engaging, which is a complement of learning motivation.

The follow-up is to enter the second phase - practical phase. In this phase, our system will support users to obtain some practical earthquake knowledge and skills, such as real scenario learning shelter map. Moreover, some new gamification elements and mechanisms based on the shelter map,
will be introduced into the system, such as exploration, time-limited missions, Easter eggs, and information sharing.

References
A Survey on The Disaster Preparedness Status of Foreign Residents in Japan

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Abstract: Japan is a county in which natural disasters occur frequently. In contrast to Japanese citizens’ high awareness for natural disaster preparedness, foreign residents in Japan are assumed to be vulnerable to the disasters due to language barriers, cultural differences and especially, lack of disaster preparedness education. In order to address this problem, the authors aim to build a multiple language mobile educational platform for foreign residents in Japan to improve their disaster preparedness and awareness. As preliminary work for the platform building, a survey was conducted in May - June, 2020 to investigate the current status of disaster preparedness and awareness of foreign residents in Japan. Two hundred fifty-one foreign residents located in 29 different prefectures of Japan responded to the survey. The results of the survey confirmed part of our assumptions that foreign residents in Japan are concerned about possible future occurrences of natural disasters but are not confident with their disaster preparedness knowledge and skills. Despite the fact that 69% of foreign residents reporting that they had participated in disaster drills, the majority of such drills were conducted in Japanese and targeting Japanese citizens. The results of the survey indicate that a multi-language mobile disaster preparedness education system would be welcomed and is needed for foreign residents in Japan.

Keywords: Survey, disaster preparedness, foreign residents in Japan, multi-language mobile learning system

1. Introduction

According to the Basic Resident Register Population and Households issued by the Japan Ministry of Internal Affairs and Communications, up to January 2, 2020, the number of foreign residents in Japan was 2,866,715, being 2.25% of the total Japanese population. The population of foreign residents in Japan has continuously increased for the past six years while the population of Japanese citizens has continuously decreased since 2009 (Japan Ministry of Internal Affairs and Communications, 2020). Obviously, foreign residents in Japan play a very important role in keeping Japan’s economy and society dynamically moving and they have made and will continue to make contributions to Japan. Thus, how to attract foreign talent and enable those people to work and live in Japan safely is linked to Japan’s sustainable development.

Japan is the country that is most affected by natural disasters. Living in such an environment, Japanese people are highly aware of disaster prevention. There are numerous disaster preparedness websites on the Internet, but most are in regular Japanese, at the most with a simple and incomplete English translation. (Japan Fire and Disaster Management Agency, 2020; Citizens' Disaster Prevention Lab, 2020; Matsue City Government, 2020; Shimane Disaster Information, 2020). Some disaster prevention websites indeed provide multiple languages, however, which in most cases are machine translations from Japanese. See website of Tokyo Disaster Prevention Information (2020): https://www.bousai.metro.tokyo.lg.jp/index.html. Disaster drills are regularly organized in schools, work-places and communities. However, almost all such drills are designed for Japanese citizens and conducted in Japanese. For those who have limited Japanese language ability such websites drills are hurdles for them. These foreign citizens are isolated from the disaster information world and are therefore vulnerable to disasters and so they are called “disaster vulnerable” (Okamoto, 2006).

In order to help foreign residents in Japan to learn disaster preparedness and equip them with disaster prevention skills, a multi-language mobile educational system for foreigners to prepare for...
disasters is being built (See Figure 1 and Figure 2). For the purpose of designing a mobile educational disaster preparedness system which can meet the needs and demands of foreign residents, a questionnaire survey on Disaster Preparedness and Awareness for Foreign Residents in Japan was conducted in May and June, 2020. Through the survey we aimed to discover to what extent foreign residents in Japan are prepared for disasters, what are their concerns and needs in preparing for disasters.

There were similar surveys conducted in the past. However, these surveys either focused on an individual area or on a certain group of foreign residents, or on an individual form of disaster. For example, Bureau of Olympic and Paralympic Games Tokyo 2020 Preparation conducted a survey to investigate awareness and needs in terms of foreigners’ safety and security in Japan (Bureau of Olympic and Paralympic Games Tokyo 2020, 2020, 2016). However, this survey targeted only foreigners in Tokyo region. Yang, Akase & Kiritai (2010) surveyed foreign residents only in Nagaoka City and Chiba City. Wei & Hisamoto (2019) investigated only international students’ awareness toward earthquakes and typhoons, not general foreign residents.

Figure 1. Technical structure of the mobile learning system for foreign residents in Japan to improve disaster awareness and preparedness

Figure 2. Learning content to reside on the mobile disaster prevention system
2. Survey methodology

2.1 Survey questions and survey purposes

The survey asked questions in the following six categories: Demographic questions; Foreign residents’ experience of disasters in Japan and home country; How foreign residents acquire knowledge of disaster preparedness; Current status of foreign resident’s preparedness for and countermeasures against disasters; How to improve awareness of foreign residents toward disasters; Structure and functions being designed for the disaster preparedness educational system.

The demographic questions include sex, age, country of origin, status of residence, current residential area and profession. Questions about foreign residents’ experience of disasters in Japan and home country include if fear of disasters affects their life plan in Japan, what kinds of disasters have been previously experienced, whether they have participated in disaster drills. Questions to ask for the status quo of foreign resident preparedness for and countermeasures against disasters in Japan is the key part of the survey as the system design is to reflect such results. We assume that foreign residents in Japan do not have much, if any, access to disaster information and disaster preparedness drills. In this part, we include questions about whether they are confident with their current disaster preparedness. The last part of the survey has questions seeking participants’ expectations for the mobile disaster educational system, e.g. what functions and content they think they need and should expect.

The survey consists of 31 questions and is written in three languages from which respondents are to choose the most familiar in order to answer. An average respondent can complete the questionnaire in seven minutes. See the link of the survey: https://survey.shimane-elearning.net/English.html.

2.2 Survey procedure

In order to test the appropriateness of the survey questions and survey design, a pilot survey was administered in February, 2020 at Shimane University among 29 international students. The printed questionnaires were distributed to students by a Japanese teacher, and the international students were asked to answer the questionnaire in class. Such a group administered survey received a very high response rate. All of the class attendees answered the questionnaire.

Based on the pilot survey and feedback from the participants, three questions were amended in order to avoid repetition and ambiguity. One single-choice question was removed and two open ended questions were added.

The revised questionnaire was then written not only in easy Japanese but also in English and Chinese in order to cover a larger sample size. The questionnaire was transcribed to Microsoft Forms and the automatically generated survey link was sent by email to potential respondents. The questionnaire can be answered on any digital device with Internet connection available.

The first author sent the questionnaire URL to foreign friends and colleagues in Japan after a brief request in an email or SNS message. They were encouraged in turn to forward the survey link to their families. The reason for asking friends or acquaintances to answer the questionnaire was because it was expected that the respondents would have a heightened sense of duty and responsibility to seriously answer the questionnaire so that the survey reliability might be guaranteed.

2.3 Data collection

The Microsoft Teams recorded every entry to the questionnaire and added up the data to the generated Excel form. Each version of the questionnaire generated a separated Excel form. On June 24, one month after the first entry to the online questionnaire, the first author downloaded three Excel forms and exported all data to one Excel form for analysis. Two entries were regarded as invalid as the respondents indicated that they were international students but they had not entered Japan and had no experiences of living in Japan.

Data of the pilot survey from the 29 international students at Shimane University was not used for this research, although we cited some of the free remarks in the discussion section of this paper.
3. Results and Discussions

3.1 Respondents profiles

Two hundred fifty-one (251) foreign residents took the survey, of whom 95 were males, 181 were females, 4 were unclear of gender, i.e. these four respondents did not wish to respond to this gender question. It is not clear why female respondents were almost double the male questionnaire participants. The reason could be that women are more likely to participate in online surveys in general (Smith, 2008). Nearly 80% of the survey participants were between the ages of 20-49. The average stay of the total respondents in Japan was 6.4 years. Thirty-eight percent of them were international students or researchers or professors at universities, while 54% of the respondents worked in the other areas in Japan as regular company employees or farm/factory helpers. The nationalities of the 251 respondents included those from China, Vietnam, Cambodia, South Korea, the United States of America, Singapore, Taiwan, France, Madagascar and five other countries.

The respondents were from 29 different prefectures in Japan. Of them, 46% were from the Tokyo metropolitan area, 20% were from the Kansai Area. These ratios are consistent with the general population distribution of foreign residents in Japan (Japan Ministry of Justice, 2020).

3.2 Foreign residents’ experience of disasters in Japan and in their home country

Among the average respondents’ stay in Japan was 6.4 years. Seventy-eight percent of the respondents with an average stay of 6.9 years in Japan have experienced some kinds of disasters in Japan and 22% of the respondents with an average stay of 4.6 years reported they had not experienced any disasters.

We used the Likert scale, not at all=1, very much=5 to measure how much fear of disasters would affect their plans to stay in Japan. The result is $M=3$, $SD=1.4$. This means that worries about disaster indeed negatively affect how foreigners plan their life and career in Japan. And the fear of disaster differs between those who stay longer and those whose stay is shorter. 71 respondents who have stayed in Japan more than 6.4 years ($M=2.7$, $SD=1.28$) compared to those who have stayed shorter than 6.4 years ($M=3.2$, $SD=1.37$) demonstrated scientifically being less fearful of disasters ($t(249)=2.652$, $p=.05$).

We consider that an effective and pertinent disaster preparedness education system for foreign residents needs to take disaster experiences in their home countries into consideration. Therefore, while we asked what disasters the participants have experienced in Japan, we also investigated their disaster experiences and disaster preparedness in their home countries. The results are as follows: 69% respondents have experienced earthquakes, 65% have experienced severe rainstorm events, and 48% have experienced storm winds or typhoons in Japan. The results remind us that disaster preparedness education should focus on disasters such as earthquakes, rainstorms, storm wind/typhoons and floods. Disaster occurrences in participants’ home countries are different. Severe rainstorm (41%) and flood (31%) are the most commonly experienced disasters. This may suggest that when we develop disaster preparedness education content, we may need to avoid overstressing mechanism and phenomena of rainstorm and flood as foreign residents may have already experienced them before they came to Japan. See Figure 3.
Forty-nine percent of respondents reported that they had received some kind of disaster preparedness training in their home countries and 51% reported they had not. Forty-nine percent is a ratio higher than we expected. We had thought that countries like China, Vietnam, and Cambodia where natural disasters are comparatively far fewer than Japan may not pay much attention to disaster preparedness training. The data shows the assumption was wrong. See Figure 4.

In recent years the world has been more aware of disasters and has better understanding of disasters than it used to in the past. Many countries have been taking measures to improve citizens’ awareness and preparedness as regards disasters. Therefore, we assumed that the ratio of younger generations who have received disaster prevention training in home countries must be higher than for the elder generations. And the results confirmed our assumption. Figure 5 shows that 62% of respondents between ages 10–29 had already joined some kinds of disaster preparedness training, while such ratio dropped to 42% for the age group 30–39, 30% for 40–49, and 23% for the age group over 50. This trend reminds us of that young foreign residents may have a higher awareness and had already received some basic disaster preparedness training before they entered Japan.

In respondents’ home countries, earthquake (66%), and fire disaster (53%) are the most targeted training items. Among 124 respondents who had joined disaster drills in their home countries, 66% reported that they had received training for protecting themselves in case of earthquakes, and 53% said they had participated in fire disaster drills. This result shows that in other countries, disaster drills overwhelmingly focus on earthquakes and fires.
3.3 Foreign residents’ disaster preparedness in Japan

We found that the majority of foreign residents (78%) in Japan have experienced disasters and the most experienced disasters are earthquakes, rainstorms and typhoons. We asked the participants if they were confident with their current disaster preparedness knowledge and skills. In general, they did not think their current knowledge and skills were good enough for preparing for and battling with disasters ($M=2.8, SD=1.19$, $1=$Not confident at all, $5=$Extremely confident). This confirmed the previous result that fear of disaster affects foreign residents’ plan to stay in Japan.

![Figure 6. Experiences of disaster drills in Japan](image)

![Figure 7. Targets of disaster drills](image)

Although 31% of respondents reported they have never participated in any kind of disaster drill in any language in Japan, still 69% said they have disaster drill experiences. This is a ratio much higher than we expected. Even 40% recalled that they had participated in drills more than 2 times (See Figure 6). However, only 20% of the respondents who had participated in disaster drills reported that the drill was organized for foreign residents (See Figure 7).

Similar to those drills in their home countries, drills focus on earthquake and fire disaster. In our survey, 82% of disaster drill participants were trained for earthquake preparedness, and 58% were trained for fire disaster preparedness.

3.4 Preparedness for and countermeasures against disasters

![Figure 8. Familiarity with disaster preparedness information](image)

Figure 8 shows that 67% respondents know their nearest evacuation route, while 33% have no idea. But in terms of the earthquake-resistance status of their apartment or house, the familiarity
dramatically dropped to 28%. Seventy-two percent of the total survey participants have no knowledge about their house/apartment and its earthquake resistance. In addition, only 38% of respondents reported that they have the hazard map distributed by the community while the rest claimed that the map was either not distributed or they just did not know anything about any hazard map.

The answers to Question “In order to protect yourself, how have you prepared for possible future disaster occurrences?” are worrying. Sixteen percent of respondents reported that they have not prepared anything. Thirty-two percent said they had prepared appropriate disaster necessities, Fourteen percent said they have assured easy contact with their families and others should a disaster occur. Twenty seven percent said they know how to use a fire extinguisher. Twelve percent have signed up to the Disaster Prevention Mailing List run by the International Center or their local government. Thirty-two admitted that they did not even know how to set up disaster alert messages on their smart phones.

The survey also found that for foreign residents, the Internet (including SNS) (74%), TV (40%), schools and workplaces (30%) are the major resources for obtaining disaster information. This indicates that any disaster information distribution should be Internet-based or at least be available on the Internet.

3.5 Mobile disaster preparedness tutorial system

When asked what was the most effective way to improve disaster awareness and preparedness skills, 43% of the respondents regarded that organizing disaster training targeting foreign residents only is most effective. Thirty percent thought that distributing disaster preparedness information in simple-to-understand Japanese is most effective, and 26% considered that they would rather study disaster preparedness knowledge and skills themselves at any time available.

Although 74% of survey participants answered that the Internet is their major disaster and disaster preparedness information recourse, the survey discovered that 88% of foreign residents have never used any online disaster preparedness training system. Thirty respondents (12%) claimed that they had used such systems before, like AU Disaster and Tokyo Bosai in Japanese language. The result suggests a potential need for an online disaster preparedness training system. We further found that in our system being developed, “Disaster prevention skills” (64%), “Disaster knowledge” (46%), and “Useful Japanese for disaster emergencies” are the most welcomed menus. This reminds us that a successful disaster preparedness educational system should be a system that uses easy language to introduce disaster knowledge and disaster prevention skills.

Some respondents expressed their expectation or hope for other menus or content that are not listed in the system which include disaster related signs, a system in Vietnamese language …etc.

4. Conclusions and Research Limitations

This study investigated the awareness and preparedness of foreign residents in Japan toward disasters. The survey results clearly show that on average foreign residents are not confident with their current knowledge and skills to battle with disasters and that concerns toward disasters negatively influence their long-term life plans in Japan. Although earthquakes, rainstorms and typhoons are the major disasters which foreign residents have experienced, disaster drills overwhelmingly focus on earthquakes and fire disaster only. Although the Internet is the main recourse for disaster information, 88% of survey participants reported that they never used any online disaster preparedness tutorial system. They expressed expectation for a mobile disaster prevention training system with menus to introduce disaster knowledge and prevention skills in multi-language format.

This survey has its limitations. Chinese represented 70% of the total respondents, Vietnamese 22%, Cambodians 9%, while Korean respondents were only 1%. This indicates that the samples of foreign resident nationals in this survey seem to be skewed. In future research, more responses from Korean residents will be sought.
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References

Using an Outdoor Mapping Activity to Understand Geographical Features from the Perspective of Disaster Prevention

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Abstract: Preparing for natural disasters requires disaster awareness as well as disaster knowledge. An understanding of areal geographical features is necessary to prevent damage specific to a region. A study was conducted to examine the change in students’ awareness and understanding of local features through an activity of creating a disaster prevention map, a method commonly used in disaster prevention studies. The learners’ awareness of disaster prevention and understanding of local features was enhanced through the learning activity. The results revealed that proactive learning was effective in helping students understand the features of the region. The creation of a disaster prevention map with field observation activities showed that general knowledge was transformed into local knowledge. To investigate the effects of a disaster that had occurred before the study, we examined the change in disaster preparedness awareness among the learners. The results showed a change in disaster preparedness awareness among the groups less affected by the disaster.

Keywords: education for disaster prevention, geographical features, earthquakes, mobile learning, classroom practice

1. Introduction

Japan is impacted by various natural disasters that occur every year in different parts of the country. To prepare for these disasters, it is necessary to acquire disaster prevention knowledge. Earthquakes are an example of a disaster that can occur throughout Japan. Earthquakes cause various kinds of damage. In addition, personal circumstances such as risk perception and experience also emerged as significant factors related to damages of earthquakes. We focus on the areal environment and geographical features. For the purposes of this paper, we use the term “geographical features” as localized knowledge of the environment within the region based on topographical and geological conditions. Landslides in areas with high elevation changes and slopes, and tsunamis in areas near the sea, are some examples of geographical features that can be used to predict damage and provide information on disaster prevention.

Regional studies are widely used in the field of education to understand the features of a region, including its geographical features. This includes town-watching activities (Shaw & Takeuchi, 2009), in which people walk around an area and observe it. In addition, the results of these activities are widely used to create “disaster prevention maps” focusing on the hazards and preparedness in the community from the viewpoint of disaster prevention. We have been focusing on this learning activity of creating disaster prevention maps in combination with outdoor learning in students’ classes (Hatakeyama, Nagai, & Murota, 2017, 2019). These studies show that learners’ awareness of disaster prevention is enhanced through learning activities that include the creation of disaster prevention maps.
2. Objectives

In this paper, we examine whether regional learning outdoors that incorporates disaster prevention mapping can help learners understand geographical features.

The theme of the lesson was understanding the preparedness for an earthquake disaster in the area. Learners created a disaster prevention map through a town-watching activity outdoors. They recorded the information they observed in the field into a system that supports the creation of disaster prevention maps. The recorded information was used for a review based on the learners’ knowledge and experiences. The system, which works on tablet devices, supports the creation and sharing of disaster prevention maps as a result of students’ activities. Through this practice, we examined changes in the learners’ awareness and understanding of geographical features.

3. Classroom Practice

3.1 General

In this study, we conducted a class over three sessions at a high school in Chiba Prefecture from October to November 2019 (Table 1). We used the “Sonael” system (Hatakeyama, Nagai, & Murota, 2014) to create disaster prevention maps using tablet devices, which is based on the “FaLAS” system (Hatakeyama, Nagai, & Murota, 2019). The target subject was 88 students from four first-year high school classes. The classes were conducted during the same period for the entire school grade as part of a period for inquiry-based cross-disciplinary study. The homeroom teacher taught each class, and students were divided into groups of three or four for class participation.

Chiba Prefecture, where the school was located, was hit by Typhoon No. 15 in early September 2019. Due to storm damage and extensive power outage, the school was closed for few days and thus, the timing and content of the class were revised in consultation with the school. For example, the second outdoor learning activities which were originally planned for the fourth session based on reflection learning activities were canceled as sufficient time could not be allotted for them.

Mitsuhara (2018) proposes three layers of learning for disaster education: Global for basic learning, Local for authentic learning, and Individual for personalized learning. This Global-Local-Individual (GLI) model shows how learning changes depending on the content addressed in disaster education or learning. We designed each unit of the class according to the GLI model. The learning consisted of three activities: basic knowledge learning in the classrooms, an outdoor learning activity in groups, and reflection in the classrooms using the students’ records and experiences.

Table 1. Outline of the Classroom Practice

<table>
<thead>
<tr>
<th>Learning Objective</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/10 Learning Basic Knowledge</td>
<td>Watched a video, received a lecture, and study using the worksheet</td>
</tr>
<tr>
<td>11/7 Outdoor Learning Activities</td>
<td>Recorded what they observed in the system</td>
</tr>
<tr>
<td>11/14 Reflection Learning Activities</td>
<td>Reflected and discussed about areal geographical features using their records</td>
</tr>
</tbody>
</table>

3.2 Learning Basic Knowledge

Basic knowledge of earthquake hazards and areal features was taught on October 10 to learn the global layer in the GLI model. Learners watched a video presentation on the damage caused by earthquakes and the classroom features in the classroom. The homeroom teachers provided an overview of the school area’s disaster using our original booklet and explained the importance of protecting oneself and thinking about a disaster as one’s own affair, using the typhoon that had just hit the area as an example.
As a learning activity, students learned to predict the risks of earthquakes using the hazard prediction worksheet. Figure 1 shows the worksheet that presented the hypothetical situation. The illustration was quoted from a learning resource by the Yamaguchi Prefecture Board of Education (2017). The learners annotated the predicted danger on the picture in the worksheet and wrote some comments about the risks. In this activity, they confirmed their global knowledge (knowledge that is not limited to the area).

Figure 1. An example of worksheets annotated by learners

3.3 Outdoor Learning Activities

As part of the local learning layer in the GLI model, we conducted a group study of the area on November 7. The target area was 2.5 km east-west, and 1.5 km north-south, centered on the school. Each group was provided with Android tablets so that they could use the Sonael system outdoors. The tablets were connected to the server through portable Wi-Fi.

The students departed the school, learned in groups, and returned to the school. The system records three categories of information: “dangerous place in case of a disaster,” “useful place in case of a disaster,” and “other.” The teachers instructed learners to move freely within the area and actively record what they noticed in the three categories referring to an earthquake disaster event.

3.4 Reflection Learning Activities

The homeroom teachers led the reflection learning on November 14. Each group was provided with an Android device to review records of their fieldwork. The records had been aggregated by class. Each group used a worksheet to organize records that indicated local geographical features or preparedness for an earthquake disaster from their records and experiences of outdoor activities.
4. Results

4.1 Records of Outdoor Learning Activities

The learners submitted 88 hazard prediction worksheets on the first day, and the responses included a variety of hazards; some comments are considered to be less valid as the respondents are not experts on earthquake disasters. However, we decided not to make a judgment on their validity as these are assumptions that the respondents had considered. The most common risky items listed in the picture were “telephone poles,” “signs,” and “building windows.” In all, 126 records were reported from the field study: 84 were dangerous, 29 were useful in the case of a disaster, and 13 were other. The most frequently used words in the record descriptions were “evacuation,” “earthquake,” and “possible.” Some words related to typhoon damage such as “blue tarp” and “typhoon” were also recognized.

4.2 Subjective Survey

The first questionnaire was administered at the beginning of the first class on October 10, and at the end of the class on November 14. Table 2 reports the results. The questionnaire was based on a supplementary book on disaster prevention education published by the Tokyo Metropolitan Board of Education (2017). We calculated a disaster preparedness score (out of 10), with a score of 1 for yes and 0 for no. In all, 71 learners responded to the items related to disaster preparedness in the two surveys. We conducted a one-factor analysis of variance with correspondence to examine if their scores differed before and after the study; a significant difference was found ($F(1,70) = 10.846, p = .002$).

We set up three items asking about the understanding of local geographical features with a 6-point scale. We checked whether these questions differed before and after learning by a one-factor analysis of variance, and they were all significant: ($F(1, 76) = 29.554, p < .001$; $F(1, 76) = 23.614, p < .001$; $F(1, 76) = 61.392, p < .001$).

<table>
<thead>
<tr>
<th>Disaster Preparedness Score</th>
<th>N</th>
<th>Before M</th>
<th>S.D.</th>
<th>After M</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Score**</td>
<td>71</td>
<td>4.30</td>
<td>2.509</td>
<td>5.69</td>
<td>3.671</td>
</tr>
</tbody>
</table>

Table 2. Subjective Survey Before and After Learning (M: Arithmetic Mean, S.D.: Standard Deviation, **: $p < .01$)

<table>
<thead>
<tr>
<th>Learning Objectives for Geographical Features</th>
<th>N</th>
<th>Before M</th>
<th>S.D.</th>
<th>After M</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. I can describe the geography of the school’s surrounding area in detail.**</td>
<td>77</td>
<td>2.56</td>
<td>1.241</td>
<td>3.52</td>
<td>1.294</td>
</tr>
<tr>
<td>B. I can describe the damage that may occur in the area surrounding the school as a result of an earthquake in detail.**</td>
<td>77</td>
<td>2.82</td>
<td>1.335</td>
<td>3.75</td>
<td>1.319</td>
</tr>
<tr>
<td>C. I can explain how to prepare for disasters in the area surrounding the school in detail.**</td>
<td>77</td>
<td>2.30</td>
<td>1.014</td>
<td>3.49</td>
<td>1.253</td>
</tr>
</tbody>
</table>

5. Discussion

5.1 Disaster Awareness

A significant difference in disaster prevention awareness was found before and after the learning. We set the items in a pre-study subjective survey to determine the impact of a recent typhoon on the area. In all, 84 learners reported the damage over the entire area by the typhoon: power outages (87%), house damage (40%), and water stoppage (19%). Overall, 75 people or 90% of the respondents had been
impacted in some way. Power outages and water stoppage had been resolved across the region at the time of teaching the class.

We divided the 71 learners who responded to the two questionnaires into two groups: those whose houses were damaged and those who were considered to be still affected at the time of the class (sufferers of major impacts of the disaster) and those who were not affected at that time (sufferer of minor impacts of the disaster). The results are reported in Table 3. There was a significant difference between the pre- and post-learning disaster preparedness scores for the less-affected group: \(F(1, 41) = 8.899, p = .005\). In contrast, no significant difference was found in the group that had faced major impacts: \(F(1, 28) = 2.301, p = .14\). There was also no significant difference between the pre- and post-intervention disaster preparedness awareness scores between the groups: \(F(1, 69) = .002, p = .97; F(1, 69) = .621, p = .43\).

Table 3. Disaster Preparedness Score Before and After Learning (M: Arithmetic Mean, S.D.: Standard Deviation, **: \(p < .01\))

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Before M</th>
<th>S.D.</th>
<th>After M</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disaster Preparedness Score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major impact of the disaster</td>
<td>29</td>
<td>4.31</td>
<td>2.55</td>
<td>5.28</td>
<td>3.712</td>
</tr>
<tr>
<td>Minor impact of the disaster**</td>
<td>42</td>
<td>4.29</td>
<td>2.511</td>
<td>5.98</td>
<td>3.659</td>
</tr>
</tbody>
</table>

For the group that was severely impacted by the typhoon, it is possible that the disaster’s ongoing experience may have made it difficult for them to bring themselves to learn about disaster prevention. As this class was included in the school’s annual plan, we conducted it as planned, although the class schedule and number of sessions had to be revised. However, it is important to implement disaster education under conditions that allow learners to engage in disaster management, such as when there is no ongoing impact of a recent disaster.

5.2 Understanding of Geographical Features

There were significant differences between pre- and post-learning on three items related to understanding local geographical features. We analyzed the results to confirm whether this was a positive factor for learning. The relationship between the learners’ active engagement and their level of understanding of localness was examined. The groups were divided on the basis of the six-item method’s total value asking about their interest and motivation to learn after the study. Learners who were higher than the mean (12.7) were categorized as active, and those lower than the mean were categorized as passive. Table 4 shows the results of a one-factor analysis of variance. A significant difference was found between the two groups for items 1 and 2 and for item 3.

Table 4. Subjective Survey for Geographical Features Before and After Learning (M: Arithmetic Mean, S.D.: Standard Deviation, **: \(p < .01\))

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Before M</th>
<th>S.D.</th>
<th>After M</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active learner</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. I can describe the geography of the school’s surrounding area in detail.**</td>
<td>38</td>
<td>2.74</td>
<td>1.201</td>
<td>4.18</td>
<td>1.205</td>
</tr>
<tr>
<td>B. I can describe the damage that may occur in the area surrounding the school as a result of an earthquake in detail.**</td>
<td>38</td>
<td>2.97</td>
<td>1.423</td>
<td>4.37</td>
<td>1.172</td>
</tr>
<tr>
<td>C. I can explain how to prepare for disasters in the area surrounding the school in detail.**</td>
<td>38</td>
<td>2.42</td>
<td>1.004</td>
<td>4.08</td>
<td>1.282</td>
</tr>
</tbody>
</table>

Passive learner
D. I can describe the geography of the school’s surrounding area in detail.**
E. I can describe the damage that may occur in the area surrounding the school as a result of an earthquake in detail.**
F. I can explain how to prepare for disasters in the area surrounding the school in detail.**

Learners who actively engaged in the learning process were able to deepen their understanding of the region’s features and the expected damage in the region through learning compared to those reluctant to learn. The school is in the Uchibo region of Chiba Prefecture, close to the sea, but is characterized by large topographical differences. In the first worksheet, we considered general hazards not limited to the region as a global learning activity. In contrast, in the field activity, we considered hazards specific to the region. One consequence of this is that the content of the worksheets differed from the content described in the records in an actual field activity. It is possible that these worksheets could have been converted to more localized knowledge of geographical features by observing what was actually localized and what was in the area.

In addition, the worksheets conducted in the reflection session also indicated that learners were able to think about the region, suggesting that lesson design that links global knowledge to local learning is useful in understanding localities.

6. Conclusion

In this paper, we conducted an experiment to examine how the learners’ awareness of disaster prevention and their understanding of the regional geographical features were changed by creating disaster prevention maps, a method commonly used in disaster prevention learning. The results showed that learners’ awareness of disaster prevention awareness and their understanding of geographical features was enhanced.

Regarding the understanding of local features, the results showed that proactive learning was effective. It was also observed that general knowledge was transformed into local knowledge through fieldwork activities like town watching. To increase the effectiveness of the class, it is necessary to devise a way to make the learners more proactive in learning.

Concerning the typhoon that occurred just before the study, we examined the change in students’ awareness of disaster prevention. A change in disaster preparedness was observed in groups less affected by the typhoon. This suggests that it is important not to evoke more disaster experiences than necessary to implement disaster reduction education.

Acknowledgements

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Applied logic: A Mastery Learning Approach Delivered Fully Online

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Abstract: This paper describes the move to a web-based mastery approach in an elective course on applied logic offered in a public university in northern Japan. This fully online course is designed using a content and language integrated approach so that students learn both the content and English at the same time. Logical and critical thinking is laden with complex concepts and technical terminology, and so to increase the rate and degree of comprehension, a mastery learning approach was adopted. An inventory of concepts, technical terminology and skills was created. The mastery list was sequenced into concept chains moving from lower to higher level concepts. Active learning activities were created for each concept chain. Criterion-based assessment checklists were created to enable self, peer and teacher assessment. Student response to the detailed mastery list was extremely positive. Using this mastery list students were better able to monitor their progress and identify which concepts to study.

Keywords: applied logic, online learning, mastery learning, digital artefacts

1. Introduction

This paper describes the move to a mastery learning approach in a fully online applied logic course. Uncritical readers may read persuasive texts and believe the veracity of news stories, the validity of conclusions in research articles or the benefits of products in advertisements. This course aims to provide students with the ability to evaluate such texts critically and not fall victim to persuasive arguments. Students are shown how to use logic to understand and evaluate written language. By the end of the course students should be able to: (a) identify arguments, conclusions, and reasoning; (b) identify common formal and informal fallacies; and (c) evaluate whether arguments are sound or cogent.

This paper is organized as follows. Section two describes the educational context and explains the difficulties that Japanese students found when studying logic in English. Section three shows how mastery learning can provide individualized learning, enabling learners to progress at their own rate. The following section details the course design, focusing on the syllabus and the online delivery systems. Section five describes and provides examples of the two types of course activities used, namely: process-orientated and product-orientated. Section six details the student, teacher and peer feedback received. Practical advice on adopting a mastery learning approach online is given in the conclusion.

2. Background

Applied logic is an elective course for third- and fourth-year students in a public university in northern Japan. This niche university is dedicated to computer science engineering and was the first university within Japan to specialize in computer education and research. All students are required to submit their graduation thesis in English and so in tandem with the focus on computing, there is also a strong emphasis on developing English language skills. The applied logic course is a two-credit course offered once per academic year. The course is delivered in one academic quarter, eight weeks, and comprises fourteen learning sessions followed by an examination. The course registration is capped at fifty students with enrolment vastly exceeding the number of available places.
2.1 Heavy content load

Over the course students are required to understand and be able to apply propositional logic, different types of reasoning, formal and informal fallacies and causality. As all students major in computer science and engineering, and study programming, most have some familiarity with formal logic. The complexity of both the subject matter and the terminology poses a significant challenge to many students. One issue is that students who miss or cannot understand concepts in a particular session tend to fall behind, since subsequent sessions build on concepts introduced in earlier sessions. This is akin to a student studying arithmetic failing to master single digit addition but progressing to double digit addition anyway.

2.2 Language

The applied logic course is designed using a content and language integrated approach so that students learn both the content and English simultaneously. Students not only need to be able to understand and apply their knowledge of formal and informal logic, but to be able to do this in English, which is an onerous task for many. Most students taking this elective course are much more comfortable writing computer code and solving calculus problems than communicating in English. Among the students there is a lack of confidence and a lack of willingness to communicate in English. The mean TOEIC score for this cohort was 390, which places them in the Common European Framework band of B2 intermediate user (Tannenbaum and Wylie, 2013). This score may reflect their receptive ability, but does not reflect their capacity to speak as few students are able to communicate smoothly.

2.3 Comprehensibility

A key problem is the extent to which students can understand the content of the class. According to Krashen (1985), comprehensible language input is when the level of input is slightly higher than the students’ current level, which can be expressed algebraically as: $i + 1$ where $i$ represents interlanguage and $+ 1$ represents the next stage of language acquisition. However, based on student feedback from previous cohorts, the actual level is $i + \alpha$ where $\alpha$ is greater than 1. This means that the input tends to be incomprehensible without additional scaffolding provided by peers, dictionaries, and machine translation software.

3. Master learning approach

3.1 Theoretical background

In a mastery learning approach, students are required to master lower-level concepts prior to progressing to higher-level concepts (e.g. Bloom, 1971, 1985; Guskey, 2007; Slavin, 1987). In arithmetic and logic, should a student be unable to understand a foundation level concept (e.g. adding single digit numbers), then a more complex concept becomes impossible to master (e.g. adding double digit numbers). Students who are unable to understand the concepts introduced in the first session will have difficulty with those introduced in the second session. In short, failing at the first hurdle means that the second hurdle becomes impossible. This sequencing enables course content to be introduced at the point at which learning is most likely to occur. This sequencing, therefore, scaffolds learners through the zone of proximal development. Numerous researchers (e.g. Donato, 1994; Forman, 2008; Gibbons, 2009; Mariani, 1997) have applied Vygotskyan (1978: 86, cited in Yasnitsky, 2011) concept of zone of proximal development (ZPD) construct to language learners. Logical and critical thinking is laden with complex concepts and technical terminology. To increase the rate and degree of comprehension, a mastery learning approach was adopted. A mastery learning approach sorts and sequences content
(skills, knowledge or behaviours) into bitesize chunks and then presents them in sequence. Mastery is evaluated using criterion-based assessments.

3.2 Practical application

In a mastery learning approach concepts are divided into a hierarchy of levels from the easiest to the most difficult. As shown in Figure 1, a five-step process is adopted.

![Figure 1: Development of output activities](image)

To begin a mastery approach, an inventory of concepts, technical terminology and skills needs to be created. The mastery list is sequenced into concept chains moving from lower- to higher-level concepts. These items are then sequenced into a concept chain. An example of a concept chain in applied logic is: true, false, truth value, declarative statement, premise, conclusion, logical indicator, inference, inference bar. To understand truth value, it is necessary to know the two values of true and false. To identify premises and conclusions, it is necessary to know what a declarative statement is, and to know that only declarative statements carry truth value. Once the concept chains are created, input activities (e.g. reading, listening and watching) and output activities (e.g. speaking, writing and creating) are designed to provide students with opportunities to apply their newly-acquired knowledge. Output activities can be considered active learning (Bonwell and Eison, 1991). Activities incorporated into the course website include participating in opinion polls, working in pairs or small groups, and creating audio or video presentations. Active learning activities were created for each session. Criterion-based assessment checklists based on the mastery list were created to enable self, peer and teacher assessment.

4. Course design

4.1 Syllabus

The syllabus is divided into three blocks: identifying arguments, identifying fallacies and evaluating arguments. The course is front-loaded with technical terminology and logical concepts with the first five sessions being particularly demanding in terms of new terms and concepts. These terms and concepts are revisited numerous times throughout the course to reinforce and refine understanding and application (González Fernández and Schmitt, 2017). The course quickly moves from a knowledge-gaining focus to an application-focus with students being expected to apply their newly-gained knowledge. Initially this knowledge is applied to short simple texts, but as the course progresses longer and more complex texts are used. The list below provides an indication of the type of concepts covered:

- Reasoning: deductive, inductive, abductive, …
- Valid propositional forms: *modus ponens*, hypothetical syllogism,…
- Formal fallacies: affirming the consequent, undistributed middle term,…
- Informal fallacies: *ad hominem*, *ad populum*, *equivocation*,…
- Causes: proximal, distal, necessary, sufficient,…
- Paradoxes: Liar, Sorites, Heap,…
- Cognitive biases: anchoring, confirmation, framing,…
A flipped classroom was adopted to maximize the effectiveness of synchronous teaching sessions (Bergmann and Sams, 2012). This course is designed to function either fully online or in blended mode. In the blended mode, face-to-face class time is dedicated to discussion in pairs, groups or whole class. These discussions help to reinforce the students’ understanding of logical concepts and test their ability to apply these concepts to various texts.

4.2 Open-access course website

A dedicated open-access course website was created using a mobile-first approach. A dark theme was chosen for the website in line with the results of a student preference survey. In earlier versions of this course, materials were delivered piecemeal, so all students studied the same concepts simultaneously. In this open-access version, students can access all learning materials from the outset of the course. This enables those students who want to progress faster or those who want to spend more time studying the materials in advance to do so. Concise descriptions of most concepts covered are now also available online in English and so students struggling to understand English can use software to simplify or translate the texts. By reading a translated or simplified version first, students are able to create a schema to help them comprehend the actual text.

4.3 Learning management system

The course website is used in conjunction with a learning management system (LMS) maintained by the university. Students are automatically enrolled in the LMS and all assessments and assignments are submitted through the LMS. Figure 2 shows a screenshot of the one question from a unit quiz, which is housed on the LMS. To enable students to check their mastery of concepts, a large question bank was created. In each session, quizzes are available for students. Students can take the multiple-choice quizzes multiple times. However, each time a quiz is initiated a different set of questions is generated from the extensive question bank. This provides students with multiple opportunities to achieve mastery.

![Figure 2: Screenshot of mastery learning question on validity and truth](image)

5. Course activities

Course activities can be classified into two types: (1) process-orientated activities in which students are engaged in the process of learning, and (2) product-orientated activities in which the primary purpose is to create a digital artefact, such as a video file, as evidence of learning. In both sets of activities, open and closed questions are used to promote logical and critical thinking (Wilhelm, 2014).
5.1 Process-orientated activities

Process-orientated activities are used to get students to understand, explain, analyze and evaluate. Students are encouraged (but not forced) to work in pairs. Some examples of process-orientated activities include self-reflection, problem-solving, pairwork and groupwork.

The course website is divided into ten units or webpages. Emoticons are used to show students the type of activities (e.g. thinking, watching, reading). Each unit begins with a list of objectives and finishes with a revision slot (Blake, 2018). The objectives help focus students and align student expectations with the course objectives. The revision slot encourages students to evaluate the degree to which they have achieved the stated objectives. The revision activity can be in the form of a list of questions to answer, or problems to solve, or memory prompts, an example of which is shown in Figure 3.

![Figure 3: Revision prompts to enable students to recall types of arguments and reasoning](image)

Group projects online help to create confidence and challenge (Lieberman, 2018). Asynchronous group work is challenging socially, administratively and logistically (Chang and Kang, 2016). When groups collaborate to create a written document using Google documents, it is easy for the tutor to monitor participation by checking the revision history (Lieberman, 2018). Wikis can be used in a similar manner. Figure 4 shows the diagram for an activity that can be used for pair or group work. This diagram of a causal network uses C1 to C4 represent causes and E1 for the effect. The diagram serves as a vehicle for students to recall terminology related to causality, such as root, distal, proximal, necessary and sufficient.

![Figure 4: Diagram to enable recall of vocabulary to describe causes](image)

5.2 Product-orientated activities

Each product-orientated activity results in the creation of a digital artefact. Digital artefacts are digital files produced in educational settings (Barton and Collins, 1997). The submitted software, reports and videos are, therefore, digital artefacts. These are stored as plain text, rich text, audio or video files. Being digital, these artefacts can be edited, adapted and reused. This means that subject to permission, an artefact submitted for an assessment or assignment can be reused as course material. It is time-consuming for a teacher to create fifty examples, but setting fifty students the task of creating one example, not only produces fifty examples quickly, but provides students with a motivating purpose for creating a text for a real audience rather than simply producing material for assessment purposes. Axiomatically, the examples need to be checked to provide feedback to its creator and to identify which materials can be used as teaching material. Examples of student-created text files are given below.
Arguments and analyses created by students to show their understanding of different types of arguments and fallacies can be repurposed. Figure 5 shows a student-created argument that is repurposed as an assignment while Figure 6 shows a student-created analysis of an argument taken from a cartoon created during the run-up to the 2016 United States presidential election.

**Argument 1**

Evaluate and name the following short argument. Identify the conclusion, evaluate the truth value of the statements and validity of the argument. If a fallacy is present, name it.

If Java language is running, then the function of C++ language is used. If the function of C++ language is used, then we can utilize C language. Therefore, If Java language is running, we can utilize C language.

**Figure 5:** Student-created assignment.

Students also created audio explanations in both English and Japanese for each of the 108 concepts covered in this course. These will be hyperlinked to the terms in the course website so future cohorts can access these on demand. Some video explanations have also been created. The most popular videos are animated slideshows with narration.

A novel learning activity is annotating logical features using tailormade html-like markup tags. Students can submit their annotated texts into an online argument analyzer, which visualizes the tags and displays explanations of the features (Blake, 2019).

**Figure 6:** Extract from teaching materials inspired by student work

### 6. Course evaluation

Student, peer and teacher evaluation was carried out. Student evaluation of the new course format was positive. In formative student feedback questionnaires administered through the LMS, students stated that they liked the following:

- Paired reviews, e.g. co-creating a review
- Clarity of the 108-item mastery list
Multiple chances to obtain 100% on assessments
Not having to retake tests once a concept is mastered
Ability to self-evaluate using checklists

Feedback from the peer evaluation included the suggestion to ensure that all terminology is explained on the course website in text form to ensure students can easily source translations. Other comments related to typographic and spelling errors that are easily addressed.

For the course tutor there was a considerable upfront time cost in terms of creating the system and developing the online materials. The burden of rapid materials creation was ameliorated somewhat by incorporating student-created digital artefacts. However, this still incurred a significant time cost to check the quality of the content, standardize the format and upload the materials. As the course is now fully online, in future courses the tutor can choose to deliver classes face-to-face or online without incurring any significant time cost.

7. Conclusion

In summary, the mastery learning approach is based on pedagogically sound principles, but the operationalization is challenging logistically and technologically. The rapid development and deployment of an online course was made possible by carefully structuring student assignments so that the materials created in earlier units could be transformed into activities in later units or in the next iteration of the course. Based on the lessons learned, eight suggestions for anyone designing an online mastery learning course using student-created digital artefacts are listed below.

1. Create a mastery list of the knowledge, skills and behaviours required.
2. Provide measurable objectives which can be tested.
3. Get students to create artefacts as assignments or assessments.
4. Write clear rubrics to get the best quality artefacts.
5. Assess artefacts using clear criteria.
6. Create materials and tests from artefacts.
7. Include a unit review for students to check their understanding themselves.
8. Provide a running tally of concepts covered, e.g. 52 out of 108 concepts.

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Teaching Elementary Logic in General Education in Taiwan

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Abstract: Designing curriculum for courses on logical thinking in colleges and universities is not easy. It is also a challenge to those lecturers who teach informal logic (including critical thinking) and impart the objective tools of analyzing and evaluating arguments. In this paper, we first investigate what content should be included in a course on logical thinking. This is a research which aims at understanding the level of satisfaction of students who are enrolled in the Language and Logic course at the Yuan Ze University, in terms of learning effectiveness. This paper will elucidate the results of applying teaching practice research on courses about logical thinking and consists of two parts. In the first part, we explore the organization of the course which comprises formal logic and critical thinking. The second part presents the learning effectiveness and learning satisfaction of delivering formal logic in the course.

Keywords: Elementary Logic, critical thinking, learning effectiveness, learning satisfaction, teaching practice research.

1. Introduction

In the general education curriculum, logical thinking courses are classified as a core field. Although the names of the courses are slightly different, their common purpose is to cultivate the basic logical thinking ability of college students. But what exactly is a basic logical thinking ability? From the perspective of developmental psychology, a child’s logical thinking ability develops in a gradual manner as the child develops. A logical thinking ability refers to the ability to solve mathematical and logical operations. Children implicitly adopt basic logical operations to perform deduction rather than calculation in their processes of learning arithmetic and engaging in temporal reasoning and geometrical reasoning. In other words, the ability to engage in logical thinking develops as a child grows older and this ability gradually permeates their thinking in everyday life. Compared with the ability to perform mathematical calculations, the ability of logical thinking is a cognitive ability or cognitive process that does not require special learning. It is not only an ability to perform mathematical operations.2

In this sense, students who have studied in colleges and universities obviously have a considerable ability to reason, think, and argue logically. When students take courses in related fields, they can apply the cognitive skills they already possess to solve problems in the new course. However, the various topics and arguments discussed in the relevant courses of colleges and universities are mostly expressed and stated through natural language, such as English and Chinese. When solving problems, most of the students use their own language (natural language) to derive schema or symbolic representation are often used as auxiliaries.

It is necessary to cultivate the literacy of logical thinking and scientific thinking in general education, but I believe that it is not necessary to achieve this goal by taking a complete course on logical thinking. I even proposed a question in order to clarify the special status of courses on logical thinking, this being “which courses in higher education cannot be used to cultivate students’ literacy of

2Although there is still academic controversy surrounding this statement, well-known child development psychology is based on the research results of the 20th century development psychologist Jean Piaget. Piaget's view of knowledge and logic is very different from the logic of traditional philosophy. Well-known related research is (Bärbel & Piaget 1964).
logical thinking?” A possible answer might be “all courses in higher education can be used to cultivate students’ literacy of logical thinking”.

Exactly what should be taught in a course on logical thinking? We think that teaching elementary logic in a scientific way is necessary and the materials of elementary logic should be scientific as well because if an instructor doesn’t deliver specific scientific materials in a course on logical thinking, many students attempt to bring their “personal logic” to the course to solve problems when they take courses on logical thinking, and moreover they usually turn a de facto closed-ended question into an open-ended one which makes these questions controversial between students. If instructors do not introduce objective methods of explaining, deriving, and proving abstract issues, then instructors have to persuade students. Teaching logical thinking might become a spoon-fed activity in a single direction or might constitute bi-directional debates between students and lecturers. In this way, students sometimes need to choose their positions, i.e. to stand on one side rather than the other, and it may result in students not understanding what a truly persuasive argument is. Students may not even realize whether there is a way to evaluate arguments or not.

The basic content of learning logic may be: “the original possessed but not properly used abilities, the original possessed but not clear concepts”. In general education, curriculum designs for courses on logical thinking should be indicated specifically so that students can understand. However, taking the example of the curriculum of general education of Yuan Ze University taught by me, I find that its College of General Studies aims to “train students to have a basic understanding of the eight core competencies and to develop appropriately”:

1. Humanities and environmental care
2. Ethical thinking and practice
3. Perceptual and interpretive understanding
4. Logical and scientific thinking
5. Citizenship and social participation
6. Communication and teamwork
7. Critical thinking and innovation
8. Cultural learning and international perspective

In view of the above, if we try to classify courses on logical thinking, then these courses cannot be regarded as cultivating logical and scientific thinking, but can be categorized as a course to develop the other seven core competencies. In addition, any course which aims to develop core competencies can be regarded as cultivating students’ literacy of logical thinking. In the classification of disciplines, courses about logical thinking are actually more basic than other courses.

In line with this position, elementary logic is more basic than any other courses in higher education; any inference or statement in academic thinking should be a valid inference or statement. We say: “Shakespeare is a good playwright” is the opinion of a certain person. “Trump is not a good president” is the opinion expressed by another certain person. However, it is obviously problematic to allow an analyzable argument become different personal opinions. For example:

**Argument.** If Trump is a good US president, then he is a good American citizen. Trump is not really a good US citizen. Therefore, Trump is not a good US president.

The instructor should be able to explain why the argument is a “valid argument” rather than focusing on students’ judgments about “whether Trump is a good US president” or “whether Trump is a good US citizen”, let alone the positions or viewpoints of students on these two statements.

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3 I believe that the meaning of the term “elementary logic” is still debatable and it is perhaps a challenge for logicians and philosophers to study the nature of elementary logic. For example, in (Hintikka, 1995), he stated that “the belief in the status of quantification theory (first-order logic) as the true elementary (basic) logic is not unanimous. For instance, some philosophers and mathematicians have argued that second-order logic is the appropriate universal medium of mathematical theorizing.” However, what I refer to is the first-order logic when I use the term “elementary logic” in this paper.

4 “Personal logic” means the value judgments that people usually use in their thinking and inferring.

5 According to the course system used by me, the courses offered by instructors must be designed to meet the core competencies with two higher weights, so that students can select their courses. There can be no more or less than two core competencies.
When reviewing the syllabuses from different universities, it is not difficult to see that some teachers emphasize teaching content on critical thinking because they may wish to make classroom activities lively and interesting. They sometimes use debates to conduct class discussions. However, the debate process tends to have problems with different positions. In a debate, people tend to want to win rather than give up their particular position. Therefore, it is difficult to avoid taking sides. Since a basic logical thinking ability comes with age, what is the essence of the elementary logic that students have to learn in class? The answer is obviously not to learn logical thinking, because if logical thinking is a cognitive process, then logical thinking is a psychological process as one develops with age. However, it may be possible to promote this ability through relevant exercises. The answer is obviously not how to apply logical systems to reasoning, because to be able to apply logical systems to reasoning activities, one must be able to understand the logical system applied, which would be an advanced course in any curriculum.

A basic logic curriculum design should include the original possessed but not properly used ability. Teaching elementary logic, where the scope of the subject has been defined properly, can help learners understand some relevant principles and logical notions about logic, and they can further try to systematically apply logical systems to analyze and understand some specific problems. This ability to analyze and understand is possessed by human beings as a species (homo sapiens), but the use of formal methods has to be acquired, among which the usage of language can be said to be the most basic of these acquaintances. As for “the original possessed but not clear concepts”, lecturers can deliver materials about critical thinking and informal logic, which can be described using natural language to articulate these concepts. In other words, we believe that matching elementary logic and critical thinking is an important key in designing an elementary logic course; and the design of courses on logical thinking may be reduced to how to design an elementary logic course without emphasising only one side.

2. Studying Learning Effectiveness in Learning Formal Logic

Several colleges and universities have made logical thinking courses compulsory or a required course in core curriculums, for example, National Pingtung University (compulsory/required course in core curriculums), National Kaohsiung University (required course in core curriculums) and the Department of Medical Management of Chang Jung Christian University (compulsory).

In my course Logical Thinking and Argument at the National University of Kaohsiung, I delivered consecutive materials on formal logic for three semesters starting in the Spring Semester 2015 (three-semester credit hours). The material in this kind of course can be extended from propositional logic to predicate logic. Also, the scores that the students attained in their final examinations were good, and the SET scores were also above average: 4.41, 4.25, 4.44, respectively. Although the students passively absorb the content, they are eventually able to understand that there are objective tools for evaluating arguments. This shows that delivering a course on formal logic in general education is acceptable to most students at some universities if there is enough teaching time. However, it also

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6 We believe that the ability to use formal language for representation and making inferences and demonstration can be regarded as the initial application of logical systems for inference. It is not necessary to understand how to construct a logical system to be able to apply logical systems for inference. In the case of college students as learners, if they can use formal language to express and abstract logical reasoning relationships, they actually learn an important cognitive tool. (Dutilh Novaes 2012) provides a philosophical and cognitive analysis of the formal language in logic.

7 From the development history of logic, the use of formal language is not necessary to explore sophisticated logical concepts. However, the use of formal language is important for a person to be able to accurately explain and interpret the so-called "logical concept" at the level of language use, and not only to use logical concepts in the process of thinking. (See Chapter 1-3 in Dutilh Novaes 2012).

8 Elementary logic has been studied by using formal languages since 20th century. Hence, two terms "elementary logic" and "formal logic" will be used interchangeably in this paper.
dependents on the instructors’ backgrounds, because such kinds of courses cannot be executed properly if taught by instructors without appropriate training in modern logic.\footnote{I observed that the learning response to the three semester credit hour course is similar to those seen in the general education courses of the National Chung Cheng University nearly 15 years ago. The only difference is the number of students. At that time, the instructors were mainly professors, based in the Department of Philosophy, and each class comprised between 150–200 students. Students were required choose one of three courses that have a mathematical-orientation: logic, statistics, or calculus.}

Courses on logical thinking are usually two-semester credit hours in general education in Taiwan. Hence, it is not an easy job to expand the course into the area of predicate logic. However, in order to ensure students have a better understating of the scope of modern logic and possibly choose other related courses in the future, it may be possible to assist students to gain an initial understanding of predicate logic, but this will require the instructors to redesign these courses.

I initially studied the possibility of introducing material on critical thinking in my course Logical Thinking and Argument at the National University of Kaohsiung in the Spring Semester 2016 (course number 1052A). This course was initially delivered by teaching formal logic consecutively for three semesters. This course was redesigned to consist of 50% critical thinking and 50% formal logic. In addition to a higher score of 4.65 in the student evaluation of teaching (SET) scores at the end of that semester, I felt that the students had been enthusiastic about the course over the whole semester. However, it is not possible to determine whether this was caused by the fact that the author introduced materials on critical thinking into the course.

I taught two courses, Modern Logic and the Method of Thought in his first semester at Yuan Ze University (Spring Semester 2017), delivering content on formal logic in the former and critical thinking in the latter. In Modern Logic, I intended to progress to units that were designed to impart an understanding of predicate logic, however, the author refrained from doing so and instead, in the last two classes he gave lessons which reviewed propositional logic because the learning situation was not good. In the Method of Thought, in addition to content on critical thinking that is usually delivered at Shu Zen College of Medicine and Management (five-year junior colleges), I included content on linguistic analysis, such as analysis vs. synthesis, a priori vs. a posteriori, causal relations, and the indeterminacy of translation which is usually taught in the Department of Philosophy to bring the course to the level of a university degree. The SET score was 4.42.

From my past SET scores from 2014 to 2018, I found that delivering a course on logical thinking in a general education course by only teaching critical thinking does not translate to higher SET scores and conversely only teaching formal logic does not translate to lower SET scores. However, a course consisting of both critical thinking and formal logic could satisfy the general requirements of most students. Hence, I think that it is improper to teach only critical thinking in a course on logic. A better way is to teach elementary logic as the main body of a course on logical thinking and the core of teaching elementary logic might be teaching formal logic with the help of material on critical thinking.

3. Teaching Practice Research Framework

Instructors hope to improve their teaching and improve their understanding of teaching through teaching practice research. Teaching practice research refers to educational practice in order to improve the quality of teaching or to promote the effectiveness of students’ learning.

This teaching practice research was carried out to prove my long-term teaching practice beliefs, and further, through the final self-assessment of the students, so that the instructors can continue to observe and reflect on courses about logical thinking (including teaching about formal logic) and the effectiveness of learning related courses. This study is based on the subjects in the Language and Logic course, taught by me in the Fall Semester 2018 and the Spring Semester 2019. They are: Fall Semester 2018 Class B (1071LLCb), Spring Semester 2019 Class A (1072LLCa), Spring Semester 2019 Class B (1072LLCb). In the Fall Semester 2018, I followed the course design for the 2017 Spring Semester (1052LLC course) Logical Thinking and Argument and for classes 1071LLCa and 1071LLCb, the course comprised critical thinking (50%) and formal logic (50%). Whether the percentage of formal
logic can be increased in the future to 70% (for around 1 – 2 weeks) so that students can learn more about formal logic is being considered. Although teaching on formal logic may not be particularly lively, when reviewing my teaching experience, the class participation and questioning frequency of the students was relatively high when entering the natural deductive method of sentential logic (propositional logic). If instructors are able to explain basic predicate logic in a similar way without delving too deeply, it will give the students a clearer perspective on logic. Therefore, I adjusted the course content to 70%-30% in the two classes of the Spring Semester 2019 (class number 1072LLCa, 1072LLCb) and then asked the students to complete the questionnaire.

Based on the research purposes of this study, I propose the following assumptions:

H1: Varying the amount of formal logic in the Language and Logic course impacts students’ learning effectiveness.

H2: Varying the amount of formal logic in the Language and Logic course impacts students’ learning satisfaction.

H3: There is a significant positive correlation between subjective self-improvement, learning effectiveness in learning formal logic, learning effectiveness and learning satisfaction of the whole course.

3.1 This study and data analysis

3.1.1 Subjects of this study

The subjects of this study were students of Yuan Ze University enrolled in the Language and Logic course, namely 1071LLCb, 1072LLCa and 1072LLCb. The total number of valid samples was 135. In terms of gender, the ratio of men to women is equal, 49.6% for men and 50.4% for women. There are five colleges in the University, namely College of Engineering, College of Management, College of Humanities and Social Sciences, College of Informatics, and College of Electrical and Communication Engineering. There are 43 participants (31.6%) from the College of Information followed by the College of Management (26.5%), the College of Engineering (22.1%) the College of Humanities and Social Sciences (15.4%), and the least number of students are from the College of Electrical and Communication Engineering (4.4%), as shown in Table 1. All students in the course must complete the course feedback form and the questionnaire after completing the course, and they should complete the SET on the YZU portal.

Table 1. Descriptive Statistic.

(n =135)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>67 (49.6)</td>
</tr>
<tr>
<td>Female</td>
<td>68 (50.4)</td>
</tr>
<tr>
<td>College</td>
<td></td>
</tr>
<tr>
<td>Engineering</td>
<td>30 (22.1)</td>
</tr>
<tr>
<td>Management</td>
<td>36 (26.5)</td>
</tr>
<tr>
<td>Humanities and Social Science</td>
<td>21 (15.4)</td>
</tr>
<tr>
<td>Information</td>
<td>43 (31.6)</td>
</tr>
<tr>
<td>Electrical and Communication Engineering</td>
<td>6 (4.4)</td>
</tr>
<tr>
<td>Grade</td>
<td></td>
</tr>
<tr>
<td>First</td>
<td>20 (14.8)</td>
</tr>
<tr>
<td>Second</td>
<td>54 (40.0)</td>
</tr>
<tr>
<td>Third</td>
<td>31 (23.0)</td>
</tr>
<tr>
<td>Fourth</td>
<td>28 (20.7)</td>
</tr>
<tr>
<td>Fifth (above)</td>
<td>2 (1.5)</td>
</tr>
</tbody>
</table>
3.1.2 Research Instrument

After referring to the relevant literature and scales, this study uses the Learning Effectiveness Questionnaire on Elementary Logic. The questionnaire comprises five parts, namely subjective self-improvement, formal logic learning effectiveness, learning effectiveness, learning satisfaction and personal background variables.

The subjective self-improvement is a self-edited scale with three items. The topics are: I think that the formal logic course after the mid-term examination improved (enhanced) my ability to understand the material about critical thinking which was delivered before the mid-term exam. I think that the formal logic course after the mid-term examination improved (increased) my ability to think about the material on critical thinking which was delivered before the mid-term exam. I think that the formal logic course after the mid-term examination improved (increased) my ability to learn the material about critical thinking which was delivered before the mid-term exam. The formal logic learning effectiveness and learning effectiveness sections are self-edited scales with 11 items for each. Learning satisfaction is based on Bhattacherjee’s (2001) definition of satisfaction with three items, measuring the students’ degree of satisfaction with the courses on logical thinking.

This questionnaire used the Likert five-point scoring model where 1 means “strongly disagree”, 2 means “disagree”, 3 means “neutral”, 4 means “agree”, and 5 means “strongly agree”. The subjects select the appropriate response to each question based on their personal feelings about the course. Reliability refers to the stability and reliability of the scale. In this study, Cronbach's $\alpha$ coefficient is used for reliability analysis, and the scores of the questions are tested for internal consistency. The higher the value, the higher the consistency of the questions. The internal consistency reliability of this questionnaire is $\alpha = 0.974$, indicating that the questionnaire has good internal consistency, and the reliability coefficients of the remaining items are shown in Table 2.

Table 2. Reliability.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cronbach’s $\alpha$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjective self-improvement</td>
<td>.914</td>
</tr>
<tr>
<td>Subjective learning effectiveness of learning formal logic</td>
<td>.946</td>
</tr>
<tr>
<td>Subjective learning effectiveness</td>
<td>.942</td>
</tr>
<tr>
<td>Subjective learning satisfaction</td>
<td>.938</td>
</tr>
<tr>
<td>All items</td>
<td>.974</td>
</tr>
</tbody>
</table>

3.1.3 Statistical analysis

Descriptive statistics: The samples in the three classes (1071LLCb, 1072LLCa and 1072LLCb) were collected through questionnaires. A total of 137 questionnaires were collected, and incomplete questionnaires were rejected, leaving a total of 135 valid questionnaires. The number and percentage of samples will be found by descriptive statistics.

3.2 Findings

The results show (Table 3and Table 4) that there is no significant difference between subjective learning effectiveness and subjective learning satisfaction across 1071LLCb, 1072LLCa, and 1072LLCb. In other words, there is no difference in the results for the course with 70%+30% formal logic tuition and of the course with 50%+50% formal logic tuition.

The correlations between subjective learning satisfaction, subjective learning effectiveness of learning formal logic, subjective learning effectiveness, and subjective self-improvement are as follows:

1. Subjective self-improvement and subjective learning effectiveness of learning formal logic are significantly positively correlated. This shows that the higher the subjective self-improvement scores, the higher the subjective learning effectiveness scores for learning formal logic.
(2) Subjective self-improvement and subjective learning effectiveness are significantly positively correlated. This shows that the higher the subjective self-improvement scores, the higher the subjective learning effectiveness scores.

(3) Subjective self-improvement and subjective learning satisfaction are significantly positively correlated. This shows that the higher the subjective self-improvement scores, the higher the subjective learning satisfaction scores.

(4) Subjective learning effectiveness of learning formal logic and subjective learning effectiveness are significantly positively correlated. This shows that the higher the subjective learning effectiveness of learning formal logic scores, the higher the subjective learning effectiveness scores.

(5) Subjective learning effectiveness of learning formal logic and subjective learning satisfaction are significantly positively correlated. This shows that the higher the subjective learning effectiveness of learning formal logic scores, the higher the subjective learning satisfaction scores.

Table 3. 1071B vs. 1072 AB One-way analysis of variance

<table>
<thead>
<tr>
<th>Class</th>
<th>number</th>
<th>mean</th>
<th>SD</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjective learning</td>
<td>1071B</td>
<td>50</td>
<td>3.76</td>
<td>.60</td>
<td>.343</td>
</tr>
<tr>
<td>learning</td>
<td>1072A</td>
<td>44</td>
<td>3.68</td>
<td>.66</td>
<td>.711</td>
</tr>
<tr>
<td>effectiveness</td>
<td>1072B</td>
<td>36</td>
<td>3.67</td>
<td>.49</td>
<td>.097</td>
</tr>
<tr>
<td>Subjective learning</td>
<td>1071B</td>
<td>49</td>
<td>3.95</td>
<td>.71</td>
<td>.908</td>
</tr>
<tr>
<td>learning</td>
<td>1072A</td>
<td>44</td>
<td>3.98</td>
<td>.75</td>
<td>.908</td>
</tr>
<tr>
<td>satisfaction</td>
<td>1072B</td>
<td>3</td>
<td>4.01</td>
<td>.57</td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Pearson Correlation (1072A and 1072B)

<table>
<thead>
<tr>
<th></th>
<th>Subjective learning effectiveness</th>
<th>Subjective learning effectiveness of learning formal logic</th>
<th>Subjective learning effectiveness</th>
<th>Subjective learning satisfaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjective learning</td>
<td>1</td>
<td>.590***</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>effectiveness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>learning effectiveness</td>
<td>.537***</td>
<td>.961***</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>of learning formal logic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subjective learning</td>
<td>.503***</td>
<td>.778***</td>
<td>.778***</td>
<td>1</td>
</tr>
<tr>
<td>effectiveness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subjective learning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>satisfaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Discussion

Hypotheses 1 and 2 are not accepted in this study. I observed that there is no difference between the two courses with different amounts of formal logic tuition. Instructors can decide to include 70%+30% or 50%+50% formal logic in their courses because the different percentages do not affect students' learning effectiveness and learning satisfaction.

According to my past experience and observations of my previous courses, students have the best learning effectiveness in the case of 50%+50%, so I assumed that learning effectiveness and learning satisfaction in the case of 50%+50% will better than the case of 70%+30%. However, this study shows that there is no difference. I infer that this is because the credits and types of courses are different (compulsory or elective courses). In courses with three-semester credit hours, students may have more time to understand the materials whereas students do not have sufficient time to understand the materials in courses with two-semester credit hours. In the case of 70%+30%, I observed that students' subjective learning effectiveness, the subjective learning effectiveness of learning formal logic, subjective self-improvement, and subjective learning satisfaction are significantly positively
correlated. I may be able to explain this because 70% of the course is about formal logic. Further research is needed to verify whether these variables are still positively correlated in the case of 50%+50%.

According to the results, hypothesis 3 of this study is accepted. There is a significant positive correlation between subjective self-improvement, subjective learning effectiveness in learning formal logic, subjective learning effectiveness, and subjective learning satisfaction of the whole course. This result will be discussed in three sections.

First, when the majority of the course (70%) is on formal logic, students have the opportunity to discover that the relevant critical thinking materials, involved in the first 30% of the course, can be analyzed by objective logical analysis without evolving into personal positions. For example, when dealing with critical thinking materials, students can also use basic tools in formal logic, such as truth tables, simple natural deductions, the non-contradiction principle in arguing and reasoning, and many more. Moreover, when students believe that the learning of formal logic has a certain enhancement in relation to their understanding, thinking and learning of critical thinking materials, they also think that their learning of formal logic has been beneficial.

Second, according to the first point, students feel courses which offer 70% formal logic enhance (understand, think, learn) and 30% critical thinking also feel the effectiveness of learning formal logic and vice versa. It can be further inferred that students are positive about the overall learning effectiveness of the course.

Third, according to my past experience and observations, learning about formal logic is not more difficult than learning about critical thinking, but the mathematical characteristics of formal logic sometimes make students feel uncomfortable in relation to their learning. Therefore, it is right to let students understand the essence of formal logic or let them understand that the discipline of formal logic can be learned independently of mathematics. For students, if they can learn formal logic part by step, learning effectiveness and learning satisfaction of the entire course will be positive.

In view of the above, a correct understanding of formal logic and its scope can help students to learn in courses about logical thinking. For example, in any argument, questions as to whether the premise itself is true or false, whether the premise is sufficient, and whether there is a good reason to justify the premise, etc. are not a matter of formal logic. Formal logic can be clearly regarded as a tool for argumentation analysis, not a tool for judging the truth or falseness of a premise. In short, students who believe they can master formal logic will understand the scope of the use of formal logic in critical thinking materials. Specifically, students can clearly distinguish the difference between critical thinking and logic.

5. Conclusion and Recommendations

Logic education is quite different from professional logic education. (The ASL Committee on Logic and Education, 1995) In Taiwan, professional logic education is a part of philosophy education. I believe that logic education should not be restricted to professional logic education only. In the general education of universities, logic is often included in the core curriculum. In the past, many instructors and students regarded the curriculum of general education as a simplified version of the curriculum of the professional department. This view is not appropriate.

The meaning and educational purpose of general education is different from those of specific departments. I believe that adopting the Department of Philosophy’s approach to logic education in general education is debatable and worth deliberation. It is not necessary to look at logic education from the perspective of philosophy education. It can even be said that if we only use the viewpoints of specific departments to look at many subjects without focusing on the current situation of higher education and general education (in Taiwan), students may be more reluctant to take these subjects and instructors are not aware that they are spoon-feeding the students.

10 https://www.ucalgary.ca/aslcle/guidelines
Instructors need to let learners learn real logic rather than allowing learners to feel that formal logic is difficult, allowing learners to avoid active learning, or allowing the course to become trivial by steering the course toward informal logic simply because the instructors want students to be more willing to attend classes. Without understanding the overall picture of logic, instructors need to work hard to correct students’ wrong impressions about logic, where students usually become involved in endless debates and discussions about value judgments.

Under such conditions, I believe that it is not appropriate to seek in-depth teaching, but to consider the breadth of the whole course. Therefore, adjustments in curriculum design are necessary to ensure students see the whole picture as much as possible. More importantly, it is necessary to pique the interest of learners to explore this subject. Over the past few years, I have found that the introduction of appropriate proportions of informal logic into the course is a useful strategy, but this does not include the most advanced research and teaching materials about informal logic, rather the basic methods of critical thinking. As stated earlier in this paper, informal logic should be a part of advanced logic, and it is not appropriate to teach these materials in general education. In the past, learners only had the impression that logic is “if P then Q” after studying this subject and students of the department of philosophy are no exception, which explains the necessity of adjusting the teaching of logic.

Compared with other relevant courses offered by other university departments, for most learners in general education, this may be their first and last opportunity to take a course in logic. Selecting the appropriate content for a logic course, as discussed in this study, needs to be done in consideration of the different levels of the students who are usually from different backgrounds, in order to evaluate what percentage of critical thinking and formal logic is the most suitable for each school, so that instructors can develop an appropriate curriculum design for different classes. Therefore, I suggest that instructors should conduct experiments and undertake research with instructors from other schools to better understand the how to organise courses on logical thinking that are suitable for their students.

The methods of teaching critical thinking and formal logic are completely different. However, all of these can be taught according to the instructors’ personal learning experiences. After the curriculum of logical thinking become the core dimension of general education, even if students want to contact this type of course, the way of past one-way lecture still make students passive. However, in a course about logical thinking, if a suitable proportion of critical thinking and formal logic content is selected, learners will have the opportunity to compare the similarities and differences between the two types of courses and to distinguish the difference between subjective beliefs and objective evaluations. This will give students the opportunity to engage in study that triggers their interest. Instructors in this field can consider using the results of this study in teaching practice.

This paper is a teaching practice study with the goal of improving the learning satisfaction and learning effectiveness of learning formal logic in general education. I explored the proportion of formal logic and critical thinking content in a course about logical thinking, and further explored whether learning formal logic can help students understand courses about logical thinking. Teaching practice research refers to educational practice in order to improve the quality of teaching or to promote the effectiveness of students’ learning (Chang 2018). However, before planning how to achieve these goals, I believe that the essence and connotation of this subject should have an appropriate explanation. As with the courses on logical thinking that we discussed in this paper, instructors should try to teach effectively before trying to improve student’ learning satisfaction. The necessary condition of effective teaching is to teach appropriate course content. As described in this paper, the appropriate content of a course about logical thinking must include appropriate tools for analysis and evaluation of arguments, including arguments in daily life that can be described by natural language.

References


Igniting Student Interest towards Educational Technology through Interest Driven Creator Theory: A Case Study at Universiti Putra Malaysia

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Abstract: This study explores students’ interest profile and the extent of their interest towards educational technology over a 14-week period. A survey was used to explore students’ interest profile while artifacts from an e-portfolio were used to understand the extent of their interest. The results revealed that students felt good about educational technology and were drawn to it. The findings proved encouraging given that it is crucial to nurture future habitual interest-driven creator teachers who are always excited to discover more about educational technology to enhance their teaching in classrooms.

Keywords: interest, educational technology, interest driven creator theory

1. Introduction

Today’s learners must acquire skills to seek new knowledge on their own and be problem solvers who are able to think creatively. They also need to effectively communicate, identify and analyse existing ideas in order to create new knowledge. Suffice to say, learners must be able to construct their own knowledge without relying too much on their teachers (Yen, Bakar, Roslan, Luan & Rahman, 2005). What remains clear is that the world is fast changing but our education systems are not moving in tandem to keep up with the change. In many countries within the Asian region, high-stakes examination takes centre-stage with important decisions being made about the future of the candidates — key examination results shape students’ choice of a future career. Rimfeld, Malanchini and Plomin (2020) warned that high-stakes examinations inadvertently push both students and teachers to focus more on examination preparation, with the common strategies of “working hard”, namely, intensive process of drilling and practicing prepackaged knowledge or past-year examination questions, and “working smart”, that is, seeking tactics and short-cuts for obtaining high grades (Wong, Jan, Toh & Chai, 2012). Consequently, the students’ educational experience is shifted away from deep learning and towards academic performances that do not necessarily reflect cognitive achievements.

2. Interest Driven Creator Theory

In view of the aforesaid challenges, Chan et al. (2018) proposed the interest driven creator (IDC) theory to address the worrying trends of students’ diminishing interest towards learning. Nurturing interest among students to learn is crucial given that recent studies have shown the strong association between interest and learning performance (Wong & Wong, 2019; Huang, Chou, Wu, Y. et al., 2020). IDC hinges on three anchors — interest, creation and habits.

In this study, we focused on the interest and creation loops as they act as an impetus to nurturing
habitual learners. As proposed by the IDC theory, the interest loop comprises three components (that is, three recursively performed learning activities) (Wong, et al., 2015; Wong et al., 2020), namely, triggering interest (through arousing students’ curiosity), immersing interest (by enabling students to experience “flow” (Csikszentmihalyi, 1990), i.e., an experience of intense emotional involvement in an activity for its own sake), and extending interest (through implementing learning activities meaningful to students). Similarly, the creation loop encompasses the following three components (Chan et al., 2019), imitating, staging and combining. The subject of study are students enrolled in a teaching degree course at Universiti Putra Malaysia, hence, it makes sense to trigger these future teachers’ interests in learning which can then lead them to creating new knowledge and ultimately becoming habitual interest-driven creator teachers in schools.

3. Objectives of the Study

This study is based on the assumption that a discrete educational technology course could trigger students’ interest in learning about educational technology. The objective of the study is to explore students’ interest profile towards educational technology. It also explores the extent of their interest towards educational technology over a 14-week period. Specifically, the following research questions will be answered:

1. What is the students’ interest profile towards educational technology?
2. What is the extent of students’ interest towards educational technology?

4. Course Description

The course, Educational Technology (FCE3401) is a compulsory course for all Physical Education major students at the Faculty of Educational Studies, Universiti Putra Malaysia. These students would progress to teach Physical Education in secondary schools upon graduation. The course aims to provide students with fundamental knowledge and skills of educational technology. The students were exposed to a 2-hour lecture and a 3-hour laboratory session per week. In the lecture, students learned about the concepts, theories, principles, development and practices in educational technology. They also learned to evaluate instructional media. For the practical sessions, students learned to create instructional media.

4.1 Instructional Context in Relation to IDC

Given that students had no prior knowledge about educational technology, the course instructor triggered students’ interests in the subject in the first week of the semester. Communication with students was done through a social media platform — WhatsApp. Two YouTube video links were given to students prior to the actual day of the first lecture. Students were also directed to visit an educational technology blog. The videos and blog gave bite size information to arouse students’ curiosity about educational technology prior to having a face to face lecture with the course instructor. More video links related to subsequent topics were shared with the students in the same way as the semester progressed to continue triggering their interests in the subject.

Students then were engaged in learning activities that would immerse students in the learning process where they go into a flow state. For example, in a learning activity about a topic on Technological Pedagogical Content Knowledge (TPACK) model, students learned about the principles of TPACK by playing a game. In this game, where they were challenged to think about which “T” (technological tool) matches a given “P” (pedagogical approach) and “C” (content) best. Through this game, students were exposed to a concrete experience where they had to decide the most suitable technological tool for a Physical Education topic. They then aligned it with the teaching approach that they would adopt in the classroom. This was where they extended their learning interest by making sense of TPACK and applying the model in a concrete and realistic situation.

During the creation stage, students were encouraged to generate ideas and construct artifacts for better learning outcomes. The stage comprises several tasks, one of which is described below as an
illustration. The task required students to work in groups of four to five students to produce a video (five to seven minutes duration) that could enhance school students’ understanding of a Physical Education topic offered in secondary schools. Students were given five weeks to complete the assignment. To help students better understand the expectations of the assignment, the instructor showed examples of educational videos on YouTube where students could imitate to form their background knowledge about the video contents. The students were also guided to prepare a story board before creating their video contents. The instructor encouraged the students to explore the various free video editing software available and choose the most appropriate one that suited their needs.

To produce an appropriate video as a teaching tool, the students needed to retrieve what they have learned about visual media and TPACK. They had the choice of either acting in the video themselves or to search for appropriate available video clips that they could put together. This stage required students to combine their newly acquired background knowledge with existing knowledge to create their own videos.

The students were given the opportunity to present their videos in groups at the end of the semester. They received feedback from the course instructor and peers at this staging phase. They also responded to questions posed by the course instructor and other group members.

5. Methods

5.1 Participants

A total of 29 Physical Education major students participated in this study. At the time of data collection, they were in their fifth semester (ages ranged between 22 and 23 years). All of them reported that they had no prior knowledge about educational technology before enrolling in the course.

5.2 Instrumentation

A survey was used to explore students’ interest profile towards educational technology. The survey used was adapted from the Mathematics Interest Inventory (MII) by Stevens and Olivárez (2005). The context of the items was changed to suit the educational technology course. MII is a seven-point scale, ranging from 1= Not at all true of me to 7= Very true of me, was used for all items in this instrument. The instrument used for this study comprised 23 items to measure students’ interest towards educational technology as shown in Table 1. There were nine negative items. The survey comprised three subscales — items 1 to 9 measured students’ positive attraction with educational technology (positive valence), items 10 to 17 measured students’ negative experience with educational technology (negative valence) and the remaining items 18 to 23 measured the time and effort students committed to educational technology. The Cronbach’s alpha of the items was .85, indicating good internal consistency for the items.

Artifacts from an e-portfolio were used to reflect the extent of their interest. Students also shared their feelings and thoughts about their educational technology journey throughout their 14 weeks course in a blog.

6. Results and Findings

6.1 Students’ interest profile towards educational technology

The overall interest mean score is 5.31 (SD = 0.85). The overall interest is much higher than the mid-point of the scale (4.00) indicating that the students had some interest in educational technology. Table 1 presents the students’ responses in regard to their interest towards educational technology measured by 23 items. Within the first sub-scale measuring their attraction with educational technology (items 1 to 9), the majority of them agreed the descriptors were very true of them. It is notable that for the descriptor “Knowing a lot about educational technology is helpful”, 65.5% of the students agreed
that this is very true of them, 72.4% agreed that it is very true that “I want to learn more about educational technology”.

In relation to the second subscale (items 10 to 17), measuring students’ negative experience associated to educational technology, the majority did not agree that the descriptors were either true or very true of them. For example, 34.5% of them felt it is not at all true while 20.7% of them felt is not true of them that they are wasting their time on educational technology. However, it should be noted that there were 24.1% and 17.2% of the respondents who felt it was very true of them and true of them respectively that they would rather be learning about something else than about educational technology.

The third subscale (items 18 to 23), measuring the amount of time and effort students committed to educational technology, the majority agreed that the descriptors were either true or very true of them. For instance, 44.8% and 17.2% of the students felt it is very true and true respectively of them to be educational technology, the majority did not agree that the descriptors were either true or very true of them.

### Table 1: Students’ Interest towards Educational Technology

<table>
<thead>
<tr>
<th>Item</th>
<th>Not at all true of me (%)</th>
<th>Not true of me (%)</th>
<th>Somewhat not true of me (%)</th>
<th>Not sure (%)</th>
<th>Somewhat true of me (%)</th>
<th>True of me (%)</th>
<th>Very true of me (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I like working on educational technology assignments</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>2. I enjoy going to the educational technology classes</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>3. I am interested in educational technology</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>7</td>
<td>7</td>
<td>17</td>
</tr>
<tr>
<td>4. Knowing a lot about educational technology is helpful</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>8</td>
<td>8</td>
<td>19</td>
</tr>
<tr>
<td>5. I feel good when it comes to working on educational technology assignments</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>6</td>
<td>17</td>
</tr>
<tr>
<td>6. I want to learn more about educational technology</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>21</td>
</tr>
<tr>
<td>7. I feel excited when a new educational technology topic is announced</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>8</td>
<td>5</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>8. I feel excited thinking about educational technology</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>7</td>
<td>7</td>
<td>17</td>
</tr>
<tr>
<td>9. I enjoy working on educational technology activities in class</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>10. I am wasting my time on educational technology*</td>
<td>10</td>
<td>6</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>11. I am bored when working on educational technology assignments*</td>
<td>24.1</td>
<td>24.1</td>
<td>3.4</td>
<td>17.2</td>
<td>6.9</td>
<td>6.9</td>
<td>17.2</td>
</tr>
<tr>
<td>12. I would rather be learning about something else than about educational technology*</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>13. I give up easily when I do not understand something about educational technology*</td>
<td>8</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>14. When working on educational technology assignments, I want to stop and start working on something else*</td>
<td>8</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>15. I am always thinking of other things when working on educational assignments*</td>
<td>24.1</td>
<td>10.3</td>
<td>10.3</td>
<td>3.4</td>
<td>6.9</td>
<td>6.9</td>
<td>17.2</td>
</tr>
<tr>
<td>16. I have difficulty paying attention during the educational technology lectures*</td>
<td>7</td>
<td>3</td>
<td>5</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>17. I struggle to understand about educational technology*</td>
<td>24.1</td>
<td>13.8</td>
<td>6.9</td>
<td>10.3</td>
<td>20.7</td>
<td>3.4</td>
<td>20.7</td>
</tr>
<tr>
<td>18. I spend as little time as possible working on educational technology assignments*</td>
<td>6</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>6</td>
</tr>
</tbody>
</table>

282
19. I spend many hours working on educational technology assignments
   1  2  0  4  7  4  11
   (3.4) (6.9) (0) (13.8) (24.1) (13.8) (37.9)

20. I work on my educational technology assignments in my spare time
   2  0  1  5  5  6  10
   (6.9) (0) (3.4) (17.2) (17.2) (20.7) (34.5)

21. I spend more hours studying about educational technology compared to other courses
   0  1  4  9  5  5  5
   (0) (3.4) (13.8) (31.0) (17.2) (17.2) (17.2)

22. I discuss about educational technology with my friends for many hours
   0  2  2  5  7  6  7
   (0) (6.9) (6.9) (17.2) (24.1) (20.7) (24.1)

23. I am involved in educational technology activities so that I can know more about this field
   1  0  0  4  6  5  13
   (3.4) (0) (0) (13.8) (20.7) (17.2) (44.8)

*Negatively worded items

6.2 Extent of students’ interest towards educational technology

The infographics as shown in Figure 1 captured two students’ feelings during the first five weeks of the course. Student #28 started in the class feeling confused and nervous but felt happy as the class progressed. She found it interesting to gain new knowledge about educational technology. Student #29 was happy and enjoyed acquiring new knowledge about new technologies especially about Metaverse—an augmented reality creation app. Students also wrote reflections about their learning experience. Most of the students felt excited because they gained new and interesting knowledge as seen from the following comments:

_I am so tired today but I still have to continue with the educational technology class today at 2pm, but thank God I still survived because we learned something interesting although all sorts of problem cropped up._

_Student #8_

_We started our class feeling happy. We are learning about VR again, yay! A guest lecturer from the Engineering Faculty taught us. She created a very interesting VR app……this attracted our interest. We were really excited when we got to experience VR. Wow…_

_Student #5_

_Today, I went to the Putra Innocreative Carnival in Technology and Learning…..I acquired a lot of new experience such as designing a task. I also got to try a gadget called VR Class. This gadget is so sophisticated and made me excited._

_Wowwwwww._

_Student #15_
7. Discussion and Conclusion

The present study explored students’ interest profile and delved more to understand the extent of their interest towards educational technology. Students felt good about educational technology and were drawn to it. The finding of this study seemed to suggest that having new experience with the subject matter appeared to have stimulated their interest. Experiencing such positive valence suggests that students have positive feelings towards educational technology which leads them to wanting to learn more about it and be involved with it (Su, Stoll & Rounds, 2019). They spent a big portion of their student learning time working on the educational technology course compared to other courses they were enrolled in. When students are engaged in tasks of interest, they develop positive feelings that reinforce that experience so that they desire to reengage in similar experiences (Su et al., 2019).

It is important for instructors to respond to what students find interesting so that more learning activities can be designed and tailored to them. Although this require more effort on the part of the instructors, it is a crucial step to take in order to nurture future habitual interest-driven creator teachers who are always excited to discover more about educational technology to enhance their teaching in classrooms.

References


Participatory Role of Discussion Forum Moderators in Learner-Centric MOOCs

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Abstract: This paper provides insights into participants’ behaviour in a Learner-Centric MOOC (LCM) titled ‘Digital Transformation in Teaching Learning Process’ that was conducted by Indian Institute of Technology Bombay and offered under the aegis of Technical Education Quality Improvement Program Phase-III, a project by the Ministry of Human Resource Development, Government of India. This study reports that the application of the LCM model has shown positive results regarding the active participation in the Discussion Forum (DF). Majority of surveyed participants have acknowledged the positive impact of the DF on their learning. Interventions implemented by the authors provided support to the Discussion Forum Moderators for enhancing participant engagement. The participation in Learner eXperience Interactions was reported with ~83% completing the corresponding graded quizzes. Further research is needed to ascertain correlation between DF and impact in the graded activities.

Keywords: Discussion Forum Moderation, MOOCs, Learner-Centric MOOC model, Learner engagement, Learner eXperience Interactions

1. Introduction

Discussion Forums (DFs) are an integral component of online courses having the potential to impact participants’ experience in a course. MOOCs generally focus more on dissemination of content than fostering interactions between the participants of the course (Naidu, 2017). The forums can be unstructured, participation in forums is low in general (Anbalagan, Kumar, & Bijlani, 2015) and interaction may also decrease in further iterations of the course (Poquet, Dowell, Brooks, & Dawson, 2018). Nonetheless, studies have pointed to a strong association between various kinds of interactions on the forum and outcomes (Bernard et al., 2009).

One of the recommended strategies to increase participation on Forum apart from creating a structured environment for threaded posts and incentivising participation is to have forum moderators (Anbalagan, Kumar, & Bijlani, 2015). It is therefore not surprising to find courses and manuals related to online teaching which acknowledge the presence and role of Discussion Forum Moderators (DFMs) for answering various kinds of queries (edX Inc, 2020; McIntyre & Mirriahi, 2020). It is observed that in many courses, the Course instructors and/or Teaching Assistants (TAs) along with the technical staff moderate and answer queries on the forum. But there is extremely little information on how to equip DFMs with the requisite skills required to not only effectively answer technical or administration queries but also to foster peer learning and elicit deeper analysis from participants about the concepts being discussed. There is limited documentation on the collaborative strategies that the course team and moderators can use to effectively orchestrate a course with thousands of participants.

2. Related work

DFs are a place where learners can resolve their doubts, learn from their peers and get a deeper
understanding of the concept being taught. It is observed that a relatively small percentage of active learners of a course participate in DFs (Breslow et al., 2013). Learners who constantly participate have a positive impact on the discussions in the forum (Wong, Pursel, Divinsky, & Jansen, 2015), have better grades, higher retention and perform better overall (Cheng, Paré, Collimore, & Joordens, 2011; Coetzee, Fox, Hearst, & Hartmann, 2014; Fielder & Siragusa, 2013).

Considering the scale of MOOCs and the volume of queries in the DF, several models have been developed to overcome challenges and facilitate interaction. The Learner eXperience Interaction (LxI) component of the Learner-Centric MOOC (LCM) model aims at encouraging participation in the DFs through focused discussions followed by a reflection quiz based on the discussions (Murthy, Warriem, Sahasrabudhe, & Iyer, 2018; Banerjee, Warriem, & Mishra, 2018). Tracking the activities of the participants is used by the instructors to plan “learning activities” (Brace-Govan, 2003). Posts that require attention from the instructors to “prioritize responses” can also be tracked (Almatrafi, Johri, & Rangwala, 2018).

This requires a team of dedicated and trained Teaching Assistants (TAs) and Discussion Forum Moderators (DFMs), who can handle the volume, establish learner-connect, and also address the diversity. DFMs play a positive role in enhancing discussions (Guan, Ysai & Hwang, 2006). This paper makes a case for orienting, managing, and supporting DFMs as they are a catalyst for creating a conducive environment for learner participation in the DFs.

3. Our Approach

The context of this study is a course titled Digital Transformation in Teaching Learning Process (DTITLP) that was conducted by Indian Institute of Technology Bombay (IIT Bombay) and offered under the aegis of Technical Education Quality Improvement Program Phase-III (TEQIP-III), a project by the Ministry of Education, Government of India, assisted by the World Bank and implemented by National Project Implementation Unit (NPIU). The DTITLP course was designed to support faculty from 100 institutions in India to use Smartboards received from TEQIP.

The course was hosted on an Online Degree portal of SWAYAM, Ministry of Education, Government of India and was offered in four batches. This study focuses on analysis of participation in the DF in the fourth iteration of the course held from 6th to 22nd April 2020. As opposed to generally low completion rates of MOOCs (Jordan, 2015), the DTITLP course had a completion rate of 68%. The course team was headed by instructors from IIT Bombay and included Teaching Associates (TAs) and Discussion Forum Moderators (DFMs) who were faculty from various institutions in the country.

The course was designed based on the LCM model, which consisted of elements such as: course videos or Learning Dialogues (LeDs), practice exercises or Learning by Doing activities (LbDs), additional learning resources or Learning eXtension Trajectories (LxTs), and Learner eXperience Interactions (LxIs) (Murthy et al., 2018). This included graded activities based on the course content, additional resources and discussions.

The course structure included a component called LxI that offered opportunities for peer interaction. LxIs comprises a Focus Question (FQ) for each week to guide the discussion on the given topic, avoid scattering of discussion threads and offer the opportunity to understand diverse viewpoints. The course included Reflection Quiz (RQ) based on the discussions around the FQ to encourage and incentivize participation in the discussion forum. To leverage the power of peer learning through focussed discussions, there was a need for DFMs to steer the discussions in a constructive manner.

3.1 DFM strategy-1: Selection of DFMs and the number of DFMs

Due to the massive nature of the course, it was decided to have a team of DFMs to support learners and manage interactions on the forum. For this purpose, the toppers from the previous batches of the course ‘Designing Learner- Centric MOOCs (LCM)’ conducted by IIT, Bombay on SWAYAM NPTEL platform were shortlisted as DFMs.

DFMs were selected through a rigorous selection process where they were asked to watch a
video from the course and then reply to three questions that were frequently asked by participants in previous iterations of the course. Their replies were assessed using an evaluation rubric and nine top performers were selected as DFMs. The strategic decision of choosing nine DFMs facilitated timetabling to handle forum activity. This ensured that there was at least one DFM per day in the forum and on days of high Forum activity additional DFMs were also assigned responsibility of managing discussions.

3.2 DFM strategy-2: Capacity building

In order to familiarize the DFMs with the modalities of the course and to inform them about their working schedule an orientation session was conducted by the course team. This strategy of organizing an initial hand-holding session offered the opportunity for deliberation on the structured approach that the DFMs could follow to facilitate conversations and exchange of ideas among the participants. In addition, a capacity building workshop was organized for the DFMs during the course. It provided an opportunity to the DFMs to understand the ways of enhancing the interactions on the forum and providing constructive discussion opportunities for participants.

3.3 DFM strategy-3: Handover policy

A strategy based on the clinical handover policy was implemented to ensure efficient communication among the DFMs when the forum responsibility was transferred. In order to ensure that the DFMs were updated with the happenings in the forum, a daily debrief session was held at the end of the day between the DFM of the day and the DFM for the following day. During the session, the DFM of the day described her/his experience, identified the post of the day, conveyed details about the unanswered queries or about any aspects of the forum that needed attention. The record of unanswered posts was maintained in a shared document for easy and convenient reference. The results of implementing these strategies and interventions are documented in the next sections.

4. Research Method

This study is based on quantitative analysis of data gathered from the course. The research questions that we attempt to answer are as follows:

1. What are participants' perceptions of the Discussion Forum?
2. What are participants' perceptions of the Discussion Forum moderation?

4.1 Sample

A total of 2986 participants from 69 technical institutions across India registered for the fourth iteration of the course. Out of these registered participants, 2064 were active participants. Active participants are those who logged in to the course at least once. Out of this, 533 participants have registered onto the DF of the MOOC platform.

4.2 Instrument

We collected data based on a survey questionnaire that was sent to all the participants at the end of the course. A total of 175 participants filled the survey and this data is being used as an input for purposive sampling. In addition, we have supplemented data from SWAYAM logs. The survey was developed to determine the participants' perception regarding the DF and DFM. The survey included a blend of questions regarding participants' perceptions of the DF and the aspects of DF like FQ, RQ, Moderation, that allowed the participants to record their responses on a five-point Likert scale (Strongly Disagree-Strongly Agree).
5. Data Analysis and Discussion

The responses received through the survey form were analysed to understand participants’ perception regarding DF and DF moderation. In this section, we present an interpretation of the results in light of the research questions.

5.1. Demographic data and frequency of posting

26% of the active participants, who registered onto the forum, have posted a total of 3912 posts. After removing the duplicate posts, 92% of total posts had more than three words and 8.17% posts had three or more replies.

22% of total surveyed participants indicated that they have posted almost daily on the forum, 35% have posted several times a week, and 39% have posted at least once during the course. The survey was answered by 98 Male participants and 75 female participants, 42% of female participants and 21% of male participants have indicated that they have posted at least once on the forum. The data logs from the portal show that among the top 15 participants with the most posts, 12 were male participants.

The top 40 participants who have posted the most number of posts on the DF (16 participants with 17-86 posts and the next 24 participants with 11-16 messages) have scored > 78% in the graded activities. The survey has a fairly balanced response which was answered by the top and average scorers and those who posted with varying levels of frequency- several times a day to not a single post.

5.2 Analysis of the responses

- **Focus question as a motivating factor:** The LxI components of the LCM Model had a major role to play in encouraging participation. 45% indicated that FQs and 75% indicated that RQs based on these focus questions were motivating factors. 83% of active participants completed the corresponding RQs that were based on the FQs. 26% acknowledged DFM support as a factor that encouraged them to post on the forum. The interventions that were implemented were directed towards orienting and supporting the DFMs to support participants on the DF.

- **Impact of DF on performance expectancy:** 76% of surveyed participants believe that the forum had a positive impact on their learning. Figure 1 indicates participants’ perception of the advantage they have gained after using the forum. 78% feel that the forum enabled them to understand course concepts related to the usage of Smartboards and pedagogical strategies. This in turn, helped them increase their performance in the graded activities (69%).

![Figure 1. Participants’ performance expectancy](image)

The participant feedback regarding the three aspects of DF usability is quite encouraging (see Figure 2). 75% participants reported that DF helped in developing their thinking skills and 76% agreed that DF offered opportunities to connect and interact with the peers. 68% which is a significant number of participants responded that interactions on the DF helped address misconceptions that they faced during the course run.
The survey included a question to obtain participants’ feedback regarding the support provided by DFMs. While 12% felt that assistance from DFMs was lacking, 68% of the participants agreed or strongly agreed that assistance from DFMs was available. The strategy of ‘One DFM a day’ ensured that participant queries were answered.

6. Conclusion and Future work

The paper provides few insights into the participants’ perception of DF. The analysis of the survey data suggests that the DF moderation helped in enhancing participant engagement with DF. This fostered peer interaction and created fertile grounds for better assimilation of course content. By implementing strategies related to incorporation of learner-centric principles as well as DFM management and training; forum can be made livelier and participants’ experience can be enhanced. While this research paper focuses on data from a preliminary survey, it is work in progress. Future study will include quantitative and qualitative analysis of the most active discussion threads and the relation between the frequency, kinds of interactions, and the certification.

Acknowledgments

We are grateful for the support provided by the Education Technology Department, IIT Bombay. We acknowledge the team at the Online Degree portal for the technical support and TEQIP III project for the financial support. We also acknowledge the support provided by Dr. Anchal Garg, Dr. Jayakrishnan M, Nitin Ayer, Ajita Deshmukh, and Ambily Joseph.

References


Abstract: Much effort has been invested to drive students’ career choices in the fields of science, technology, engineering and mathematics (STEM), however the targeted outcome of the effort has not yet been fully achieved. The understanding towards the students’ career choice intention in STEM is scarce despite the great importance to identify students’ career choices. This suggests that there is a need to improve the measurement of the factors in the Theory of Planned Behaviour (TPB) to better explain students’ intention towards deciding STEM career choices. Therefore, the objective of the current paper study is to develop a TPB questionnaire to assess secondary school students’ career choices in STEM. Questionnaire measures the factors that influence career choices among students in STEM namely attitude towards career choice, subjective norm, perceived behavioural control, and career choice intention. The development of the questionnaire involved three pilot tests, namely Study 1 (n = 56), Study 2 (n = 32), and Study 3 (n = 45). Multiple modifications were done based on the pilot test results to improve the questionnaire so that it is apt for the target sample of the research and suitable for the context of the research. Further research can be done using confirmatory factor analysis and provide external evidence of validity for the questionnaire. This is essentially important as it would help the researchers to develop a valid and reliable research instrument to measure students’ career choices in STEM.

Keywords: Theory of Planned Behaviour, Career Choices, STEM, Secondary Schools

1. Introduction

Career choice is unique across individuals in terms of what occupation each individual opts to pursue in life (Lau et al., 2018). According to Razali et al. (2017), there is a high demand for talents in the fields of science, technology, engineering and mathematics (STEM). It is reported that the demand for STEM workers is much higher than other fields in which 80% of the vacancy in the American industries are from the STEM sectors (Razali et al., 2017). Similarly, it was estimated that Malaysia would need eight million people to fill the STEM sectors by 2050 (Academy of Sciences Malaysia, 2017).

In view of the crucial need for STEM workers in the global and local industries, the Malaysian Ministry of Education (MoE) has mapped out a detailed plan in its education blueprint to produce sufficient human capital for the STEM workforce (MoE, 2013). The MoE is aware that students should be educated about career opportunities in STEM in secondary schools. In Malaysia, the STEM curricula in the education system encompass subjects such as Technical Communication Graphics, Medical, Biochemistry, Computing and Information Systems, and Computer Science (Shahali et al., 2017).

The MoE also creates awareness about STEM among students in secondary schools to expose them to the career choices in STEM related industries (MoE, 2013; Razali et al., 2017; Shahali et al., 2017). In the effort to prepare students for STEM careers, the MoE works closely with the private sectors and other government agencies on the complementary STEM initiatives via the National STEM Action Plan (Shahali et al., 2017). The main purpose of these initiatives is to amplify STEM awareness and the diversity of career opportunities in STEM, and to bridge the gap between STEM demand and supply in Malaysia (Shahali et al., 2017).

Outreach Programmes and STEM Mentor-Mentee Programmes are among of the most widely implemented STEM initiatives to increase students’ exposure to STEM careers. These programmes are...
normally done in collaboration with STEM related agencies and tertiary institutions (Shahali et al., 2017). Besides, there are also other complementary STEM initiatives such as School-Parents Collaboration, STEM conference and colloquiums, and volunteering programmes that involve teachers, parents, educators, industry players and the public. These initiatives do not only focus on students, but also to create STEM awareness among parents and teachers who are important in students’ career choices. This also provides platforms for them to be better informed about STEM career opportunities so that they could also play a part to encourage students’ involvement in the STEM workforce in the future (Shahali et al., 2017).

Although much effort has been invested to drive students’ career choices in STEM, the targeted outcome of the effort has not yet been fully achieved (Academy of Sciences Malaysia, 2017; MoE, 2013; Shahali et al., 2017). In contrast to the initiatives to promote STEM at school level, the number of students in STEM also has dropped since 2010 (Chin, 2017). Therefore, align with the effort of the Malaysian education system to create a STEM-oriented learning environment to produce more STEM talents, there is a need to understand the reasons that lead the students to choose a career more precisely. The theory of planned behaviour (TPB) is among the most prevalent theories that has been widely used to measure students’ career choices (Bidin et al., 2012; Sieger & Monsen, 2015; Solesvik, 2011; Wen et al., 2018).

However, the understanding towards the students’ career choice intention in STEM is scarce despite the great importance to identify students’ career choices. TPB is very much established to assess students’ career choices, but it is argued that TPB might not be ideal in all empirical settings (Sieger & Monsen, 2015). According to Sieger and Monsen (2015), although TPB has been widely used across different settings, it remains unclear whether setting variations would affect the usage of the TPB questionnaire particularly for career choice intentions. This suggests that there is a need to improve the measurement of TPB to better explain students’ intention towards making STEM career choices (Sieger & Monsen, 2015). As such, this study aimed to develop a TPB questionnaire to assess secondary school students’ career choices in STEM.

2. Literature Review

The TPB as shown in Figure 1 is one of the most widely used theoretical models that explains an individual’s goal to execute certain behaviour (Ajzen, 1991). Bidin et al. (2012) suggested that TPB is an intention-based model which is powerful in explaining behaviour via intention. The TPB consists of three determining factors of intention, namely attitude, subjective norm and perceived behavioural control (Ajzen, 1991).

![Figure 1. Theory of planned behaviour (TPB), retrieved from Ajzen (1991).](image)
In Ajzen (1991), intention is described as an accurate predictor of actual behaviour in the TPB. In TPB, intention refers to how hard a person is willing to put effort and attempt to execute a particular behaviour (Ajzen, 1991; Bidin et al., 2012). González et al. (2012) defined intention as an individual’s decision to perform a behaviour in the future. In this study, intention is operationalised as career choice intention to indicate students’ plan to choose a STEM career in the future.

Intention is in turn influenced by attitude, subjective norm and perceived behavioural control. According to Ajzen, attitude refers to an individual’s evaluation (positive or negative) towards a behaviour and its outcome. Bidin et al. (2012) explained that attitude is determined by a person’s beliefs about the expected outcomes resulting from the intentional behaviour. The present study specifies attitude in TPB as attitude towards career choice to indicate students’ student’s positive or negative evaluation of their intention of choosing a career in STEM.

The second determinant of intention is subjective norm (Ajzen, 1991). Subjective norm is described as a person’s perception of the judgement or expectations of important people in their lives (Ajzen, 1991; Bidin et al., 2012). In other words, it refers to the social pressure that an individual perceives from people around them such as family members, teachers and peers upon performing a certain behaviour. In this study, subjective norm can be denoted as students’ perception concerning the judgement of parents, teachers and friends towards their career choices in STEM.

Perceived behavioural control is defined as the perceived ability to conduct a behaviour (Ajzen, 1991). It is referred to as a person’s confidence and sense of control over his ability to perform the behaviour (González et al., 2012; Wen et al., 2018). Hence, perceived behavioural control in this study can be explained as a student’s perception on the degree of easiness and difficulty, as well as confidence and perceived ability in choosing a career in STEM.

In the literature, most of the studies done using TPB were based on the guidelines provided by the TPB author to construct TPB questionnaire (Ajzen, 2002). It has been a common practice that the TPB scales have been repeatedly adopted and adapted based on the respective needs and contexts of their research according to Ajzen’s guidelines. Besides Ajzen (2002), Francis et al. (2004) also provided a detailed manual on how to design a TPB questionnaire. In the manual by Francis et al. (2014), a comprehensive explanation on the TPB psychometrics properties is clearly stated with a step-by-step guideline on how to develop a TPB questionnaire (González et al., 2012).

According to González et al. (2012), TPB has strong empirical evidence to support the relationship between the variables in the TPB and career choices. TPB is one of the most prevalent theories that has been widely employed in a wide range of research areas because it is a practical theory that can be applied in various contexts (Bidin et al., 2012). This theory is particularly popular in research contexts such as education, marketing, banking and finance, information technology, and healthcare (Warsame & Ireri, 2016; Guo et al., 2019). Likewise, there are also many studies in the literature that used TPB in the context of career choices (Shevlin & Millar, 2006; Bidin et al., 2012; Sieger & Monsen, 2015; Wen et al., 2018).

In Malaysia, many studies have also been carried out using TPB in their investigation on topics pertaining to career choices. However, most of these studies in the literature are conducted in the context of entrepreneurship among students from higher learning institutions (Ambad & Dami, 2016; Ariff et al., 2010). The present study argues that the sample of this study is unlike those in the literature, they are adolescents at the secondary school level and students studying in Malaysian secondary schools. Given that there are no specific rating scales that measure students’ STEM career choices in Malaysia using the TPB questionnaire, developing the instrument using the samples from the Malaysian student context would be much meaningful to overcome the contextual differences.

Hence, this study aimed to develop a TPB questionnaire that measures the factors that influence career choices among students in STEM that entails the constructs, namely attitude towards career choice, subjective norm, perceived behavioural control, and career choice intention. This questionnaire was developed based on the guideline recommended by the author of TPB in Ajzen (2002) as well as the manual by Francis et al. (2004). In this study, three independent pilot tests (Study 1, Study 2, & Study 3) were conducted to develop the TPB questionnaire for STEM career choices among Form Four secondary school students in Malaysia.
3. Development of TPB Questionnaire for Students’ STEM Career Choices

The initial draft of the TPB questionnaire for students’ career choices in STEM was designed according to the manual and guideline provided by Ajzen (2002) and Francis et al. (2004). The construct items in the questionnaire were formed based on the variables in the TPB by referring to the guidelines and incorporating the context of this research. It was subsequently reviewed and evaluated by three experts in this field of research with reference to the definitions of the terms and objectives of the research for its content validity. The experts commented on the items and scales to ensure they are suitable for this study and its respondents and changes were done accordingly. Table 1 shows the reliability test results of the three pilot tests. The internal consistency of the scales is presented according to each pilot study to show the development of the questionnaire at each stage, and how each scale was carefully amended after each of the pilot tests.

<table>
<thead>
<tr>
<th>Scales</th>
<th>Study 1</th>
<th>Study 2</th>
<th>Study 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of Items</td>
<td>Cronbach’s Alpha</td>
<td>Number of Items</td>
</tr>
<tr>
<td>Attitude towards Career Choice (ACC)</td>
<td>9</td>
<td>.85</td>
<td>9</td>
</tr>
<tr>
<td>Subjective Norm (SN)</td>
<td>20</td>
<td>.85</td>
<td>19</td>
</tr>
<tr>
<td>General</td>
<td>5</td>
<td>.06</td>
<td>4</td>
</tr>
<tr>
<td>Teachers</td>
<td>5</td>
<td>.77</td>
<td>5</td>
</tr>
<tr>
<td>Parents</td>
<td>5</td>
<td>.74</td>
<td>5</td>
</tr>
<tr>
<td>Friends</td>
<td>5</td>
<td>.76</td>
<td>5</td>
</tr>
<tr>
<td>Perceived Behavioural Control (PBC)</td>
<td>9</td>
<td>.82</td>
<td>8</td>
</tr>
<tr>
<td>Career Choice Intention (CCI)</td>
<td>8</td>
<td>.97</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 1. Reliability Test Result for the Questionnaire in Study 1, Study 2 and Study 3

3.1 Study 1

Study 1 was conducted in two schools located in Kuala Lumpur, Malaysia. A total of 56 Form Four students aged 16 years old completed the questionnaire. Among the respondents in this study, 39 of them were males (69.60%) and 17 were females (30.40%). The initial TPB questionnaire used in Study 1 consisted of 46 seven-point Likert scale items, ranging from 1 (disagree) to 7 (agree). The questionnaire contained four sections with the TPB constructs, namely attitude towards career choice, subjective norm (general, teachers, parents and friends), perceived behavioural control, and career choice intention.

A reliability analysis was conducted for all the TPB constructs in Study 1 to test their internal consistency. In Table 1, the Cronbach’s alpha coefficient values for attitude towards career choice (α = .85), perceived behavioural control (α = .82), and career choice intention (α = .97) were above the recommended value of .70, hence these constructs had good internal consistency. Although the construct subjective norm shows a good overall reliability with α = .85, one of its subscales, general subjective norm recorded extremely low Cronbach’s alpha coefficient value at .06.

Improvements were done to the initial questionnaire used in Study 1 (as shown in Table 2) internal consistency of the respective constructs and resulted in the second set of TPB questionnaire for students’ career choices in STEM which was used in Study 2.
3.2 Study 2

The second set of TPB questionnaire for students’ career choices in STEM used in Study 2 is a result from Study 1. Study 2 was conducted in a school located in Selangor, Malaysia. A total of 32 Form Four students aged 16 years old completed the survey. Out of the total respondents from Study 2, 12 were male (37.50%) and 20 were female (62.50%) students.

In Study 2, the TPB questionnaire used contained 43 seven-point Likert scale items. Similar to Study 1, the questionnaire in Study 2 also comprised four sections with the TPB constructs, namely attitude towards career choice, subjective norm (general, teachers, parents and friends), perceived behavioural control, and career choice intention.

Table 1 shows the results of the reliability test for the questionnaire used in Study 2. As shown in the table, all constructs were statistically reliable. The values of Cronbach’s alpha coefficient were all beyond the recommended threshold value of .70: attitude towards career choice (α = .87), subjective norm (α = .93), perceived behavioural control (α = .94), and career choice intention (α = .97).

However, the reliability of the subscale general subjective norm remained undesirable (α = .68). Considering the subscale repeatedly showed low reliability in both Study 1 and Study 2, the general subjective norm was removed from the questionnaire. The TPB questionnaire for students’ career choices in STEM in Study 2 was improved as shown in Table 2. As a result, the total number of items was reduced to 46 items. This resulted in the second set of TPB questionnaire for students’ career choices in STEM which was used in Study 3.

3.3 Study 3

The third set of TPB questionnaire for students’ career choices in STEM used in Study 3 is a result from Study 2. Study 3 was conducted in a school located in Johor, Malaysia. A total of 45 Form Four students aged 16 years old completed the questionnaire. The respondents consisted of 33 male (73.30%) and 12 were female (26.70%) students.

The TPB questionnaire used in Study 3 contained 31 five-point Likert scale items, ranging from 1 (disagree) to 5 (agree). Similar to Study 1 and 2, the questionnaire in Study 3 also encompassed four sections with the TPB constructs, namely attitude towards career choice (α = .86), subjective norm (α = .91), perceived behavioural control (α = .85), and career choice intention (α = .89). As shown in Table 1, subjective norm only had three subscales remained, namely teachers (α = .73), parents (α = .85), and friends (α = .92). The revisions done to the questionnaire used in Study 3 were as detailed in Table 2.

As a result, all constructs and subscales in the TPB questionnaire for students’ career choices in STEM in Study 3 were beyond the recommended threshold value for reliability. This indicates that all items in the questionnaire used in Study 3 had good internal consistency. Therefore, the TPB questionnaire for students’ career choices in STEM in Study 3 is final and is considered empirically feasible to be tested for future research use and for further validation.

4. Discussion and Conclusion

This paper presents the development of a TPB questionnaire that measures the antecedents that influence students’ STEM career choices. Table 2 depicts the summary of the development of the TPB questionnaire for students’ career choices in STEM. As shown in the table, the development of the questionnaire involved three pilot tests, namely Study 1, Study 2 and Study 3. The table entails the modifications on the questionnaire including addition, removal, rewording, and rearrangement of items from Study 1 to Study 3.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Study 1 (n = 56)</th>
<th>Study 2 (n = 32)</th>
<th>Study 3 (n = 45)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Disagree) – 7 (Agree)</td>
<td>1 (Disagree) – 7 (Agree)</td>
<td>1 (Disagree) – 5 (Agree)</td>
<td></td>
</tr>
</tbody>
</table>

296
<table>
<thead>
<tr>
<th>ACC1</th>
<th>Choosing a career in STEM is good.</th>
<th>Choosing a career in STEM is good.</th>
<th>A career in STEM is good.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACC2</td>
<td>Choosing a career in STEM makes me feel good.</td>
<td>Choosing a career in STEM makes me feel good.</td>
<td>A career in STEM will make me feel good.</td>
</tr>
<tr>
<td>ACC3</td>
<td>I will feel happy if I choose a career in STEM.</td>
<td>I will feel happy if I choose a career in STEM.</td>
<td>A career in STEM will make me happy.</td>
</tr>
<tr>
<td>ACC4</td>
<td>Choosing a career in STEM is meaningful.</td>
<td>Choosing a career in STEM is meaningful.</td>
<td>A career in STEM is meaningful to me.</td>
</tr>
<tr>
<td>ACC5</td>
<td>If I choose a career in STEM, I will be respected.</td>
<td>If I choose a career in STEM, I will be respected.</td>
<td>A career in STEM will bring me respect.</td>
</tr>
<tr>
<td>ACC6</td>
<td>Good income from a STEM career is what I want.</td>
<td>Good income from a STEM career is what I want.</td>
<td>A career in STEM makes me feel proud.</td>
</tr>
<tr>
<td>ACC7</td>
<td>If I choose a career in STEM, I will have a good standard of living/lifestyle.</td>
<td>If I choose a career in STEM, I will have a good standard of living/lifestyle.</td>
<td></td>
</tr>
<tr>
<td>ACC8</td>
<td>If I choose a career in STEM, I will be proud of myself.</td>
<td>If I choose a career in STEM, I will be proud of myself.</td>
<td></td>
</tr>
<tr>
<td>ACC9</td>
<td>Making myself feel proud of my career choice in STEM is what I want.</td>
<td>Making myself feel proud of my career choice in STEM is what I want.</td>
<td></td>
</tr>
</tbody>
</table>

Note 1. No modifications from ACC1 to ACC9.

Note 1. Modifications
i) Wording
   - ACC1 to ACC5
ii) Combination
   - ACC8 & ACC9 → ACC6
iii) Removal
   - ACC6 & ACC7

<table>
<thead>
<tr>
<th>General</th>
<th>Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>SN1</td>
<td>People who are important to me think that I should choose a career in STEM.</td>
</tr>
<tr>
<td></td>
<td>I need to choose a career in STEM because the people who are important to me want me to.</td>
</tr>
<tr>
<td></td>
<td>My teachers think that I should choose a career in STEM.</td>
</tr>
<tr>
<td>SN2</td>
<td>I need to choose a career in STEM because the people who are important to me want me to.</td>
</tr>
<tr>
<td></td>
<td>I feel under pressure when people who are important to me want me to choose a career in STEM.</td>
</tr>
<tr>
<td></td>
<td>My teachers think that I should choose a career in STEM, therefore I should do so.</td>
</tr>
<tr>
<td>SN3</td>
<td>I feel under pressure when people who are important to me want me to choose a career in STEM.</td>
</tr>
<tr>
<td></td>
<td>I feel under pressure when most people like me choose a career in STEM.</td>
</tr>
<tr>
<td></td>
<td>My teachers’ advice is important to my career choice in STEM.</td>
</tr>
<tr>
<td>SN4</td>
<td>I feel under pressure when most people like me choose a career in STEM.</td>
</tr>
<tr>
<td></td>
<td>Many people choose a career in STEM, so I want to choose a STEM career too.</td>
</tr>
<tr>
<td></td>
<td>My teachers’ teaching will encourage me to choose a career in STEM.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Teachers</th>
<th>Parents</th>
</tr>
</thead>
<tbody>
<tr>
<td>SN5</td>
<td>Many people choose a career in STEM fields, so I want to choose a STEM career too.</td>
</tr>
<tr>
<td></td>
<td>My teachers think that I should choose a career in STEM.</td>
</tr>
<tr>
<td></td>
<td>My teachers’ teaching will increase my interest to choose a career in STEM.</td>
</tr>
<tr>
<td>SN6</td>
<td>My teachers think that I should choose a career in STEM.</td>
</tr>
<tr>
<td>SN7</td>
<td>When it comes to choosing a career, I feel the need to do what my teachers think I should do.</td>
</tr>
<tr>
<td>SN8</td>
<td>I listen to my teachers’ advice when it comes to choosing a career.</td>
</tr>
<tr>
<td>SN9</td>
<td>My teachers’ teaching encourages me to choose a career in STEM.</td>
</tr>
<tr>
<td>SN10</td>
<td>My teachers’ teaching improves my interest in choosing a career in STEM.</td>
</tr>
<tr>
<td>SN11</td>
<td>My parents think that I should choose a career in STEM.</td>
</tr>
<tr>
<td>SN12</td>
<td>When it comes to choosing a career, I feel the need to do what my parents think I should do.</td>
</tr>
<tr>
<td>SN13</td>
<td>I listen to my parents’ advice when it comes to choosing a career.</td>
</tr>
<tr>
<td>SN14</td>
<td>My parents encourage me to choose a career in STEM fields.</td>
</tr>
<tr>
<td>SN15</td>
<td>My parents’ encouragement improves my interest in choosing a career in STEM.</td>
</tr>
<tr>
<td>SN16</td>
<td>My friends think that I should choose a career in STEM.</td>
</tr>
<tr>
<td>SN17</td>
<td>When it comes to choosing a career, I feel the need to do what my friends think I should do.</td>
</tr>
<tr>
<td>SN18</td>
<td>I listen to my friends’ advice when it comes to choosing a career.</td>
</tr>
<tr>
<td>SN19</td>
<td>My friends encourage me to choose a career in STEM.</td>
</tr>
<tr>
<td>------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>SN20</td>
<td>My friends’ encouragement improves my interest to choose a career in STEM.</td>
</tr>
<tr>
<td>1. Modification</td>
<td>1. Modification</td>
</tr>
<tr>
<td>i) Rearrangement</td>
<td>i) Wording</td>
</tr>
<tr>
<td>• SN2 to SN20 → SN1 to SN19</td>
<td>• SN6 to SN9, SN11 to SN14, SN16, SN17 &amp; SN19</td>
</tr>
<tr>
<td>ii) Removal</td>
<td>ii) Rearrangement</td>
</tr>
<tr>
<td>• SN1</td>
<td>• SN5 to SN19 → SN1 to SN15</td>
</tr>
<tr>
<td>iii) Removal</td>
<td>iii) Removal</td>
</tr>
<tr>
<td>• SN1 to SN4</td>
<td></td>
</tr>
<tr>
<td>PBC1</td>
<td>I am confident that I can choose a career in STEM.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>PBC2</td>
<td>Choosing a career in STEM is up to me.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>PBC3</td>
<td>For me to choose a career in STEM is easy.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>PBC4</td>
<td>I expect that I will have the ability to choose a career in STEM.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>PBC5</td>
<td>Having the ability would enable me to choose a career in STEM.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>PBC6</td>
<td>I expect that I will get good academic results to choose a career in STEM.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>PBC7</td>
<td>Performing well in academic would enable me to choose a career in STEM.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>PBC8</td>
<td>I expect that I will have the self-confidence to choose a career in STEM.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>PBC9</td>
<td>Having the self-confidence would enable me to choose a career in STEM.</td>
</tr>
</tbody>
</table>

Note 1. No modification on PBC1.  
2. Modification  
   i) Rearrangement  
   • PBC3 to PBC9 → PBC2 to PBC8  
   ii) Removal  
   • PBC2  
   1. Modification  
   i) Wording  
   • PBC1 to PBC4  
   ii) Combination  
   • PBC7 & PBC8 → PBC5  
   iii) Removal  
   • PBC5 & PBC6  
   iv) Addition  
   • PBC6
This paper focuses on the process of developing the questionnaire, that is, how the items and scales in the questionnaire were carefully adapted, modified and revised in each pilot test. It is important to adapt and modify the questionnaire according to the context of this study in line with the research objective to guarantee the questionnaire matches the comprehension level of the targeted respondents (Survey Research Center, 2016). The items were modified according to the results from the reliability tests in each pilot test. When the internal consistency of the scales could be improved after item modifications, the relevant items were remained. On the other hand, if the reliability of a scale remained below the recommended threshold value at .70 after item modifications, the relevant items were removed. The modifications were done based on the pilot test results to improve the questionnaire so that it is apt for the target sample and the context of the research.

As aforementioned, the understanding towards the students’ career choice intention in STEM is scarce despite the need to address students’ career choices. This paper is an initiative develop a TPB questionnaire to measure the factors that better explain students’ intention towards deciding STEM career choices. This study definitely provides a separate new context specific questionnaire with contextual details in Malaysia setting compared to TPB to assess students’ career choices in STEM. This would offer insights to not only local policy makers and stakeholders, but also add to the literature on how STEM is positioned across different contexts. As such, factors that influence students’ career choices in STEM could be emphasised in consideration of educational decisions, policy making and strategy planning in relation to STEM education.

There are also limitations to be addressed in this study. The data in the three pilot tests were collected through self-reported surveys which could have caused common method variance. Subsequent research employing a qualitative approach such as cognitive interview could help to provide a more comprehensive and in-depth understanding of the questionnaire developed. Besides, this paper only reported the initial stage of the questionnaire development, hence further research can examine the
psychometric aspects of the questionnaire. Further research could be done using confirmatory factor analysis and provide external evidence of validity for the questionnaire that would help the researchers to develop a more valid and reliable research instrument to measure students’ career choices in STEM. Consequently, it can be concluded that the results of the current study could be used for scale validation in the future research to assess students’ career choice in STEM. The validated questionnaire will be useful to investigate secondary school students’ career choices particularly in the STEM fields.

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References


Design and Development of “Slow Art” Experience for Tapaya’s Earthly Desires

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Abstract: We describe the design and development of a “slow art” experience of Rodel Tapaya’s painting, Earthly Desires, which was developed for the Microsoft HoloLens. The painting is a mix of mythological and historical imagery and can be appreciated from multiple perspectives. The experience that we designed offers viewers on a particular thread, provided by the artist himself, in which he describes how the painting emanated from the image and theme of the agimat or talisman. The experience was implemented using the Unity game engine and the Vuforia AR plugin for Unity. Due to community quarantines associated with the COVID-19 pandemic, we were not able to gather feedback from museum visitors regarding the experience but will be performed in the future.

Keywords: Augmented Reality, Earthly Desires, Slow Art

1. Introduction

Studies have shown that the average museum visitor spends from 27 to 33 seconds looking at an individual piece of art (Carbon, 2017, Smith & Smith, 2001). In recent years, though, a movement called “Slow Art” has taken root. Phil Terry, the founder of Slow Art Day, explains that “Many people don’t know how to look at and love art and are disconnected from it... By slowing down, it helps us to see art in a new way that energises rather than demoralises…” The slow art experience is defined as a style of looking that involves “heightened attention to the experience of time unfolding” (Davis, 2017). It is an encounter between the visitor and the art piece, one that rewards lingering, attention, and thought.

It is within this philosophy of slow art that we situate the work that we report in this paper. In cooperation with Filipino artist Rodel Tapaya, we design and develop a Microsoft HoloLens experience of his painting Earthly Desires. In this paper, we describe the design and development process of the experience but are unable to report on deployment as user testing was halted because of community quarantines related to COVID-19.

2. Related Literature

In 1928, Robinson (1928) wrote of the need to cater to the casual visitor. It is not enough for museums to cater to the connoisseur. Those who are well-versed in art are able to identify important pieces without assistance. As the casual visitor wanders, museums should attempt to capture their interests and fan them “into overt enjoyment.” Indeed, catering to the casual visitor is, to some, a matter of social justice. Museums should extend beyond a privileged subset and try to build community relationships, lest visitors feel dismissed or intimidated (Kinsley, 2016).

One way to build greater inclusivity and promote deeper understanding is through the use of extended reality technologies. Extended reality is the umbrella term that covers augmented reality (AR), virtual reality (VR), and mixed reality (MR). These technologies can be used for a variety of purposes: to visit a remote collection or part of a collection that visitors cannot otherwise access; to provide additional sources of information; to provide immersive, interactive experiences; and to tell stories, among others (Sylaiou, et al., 2018). Several mixed reality experiences already exist to address these different goals.
The Kremer Collection VR Museum is an example of a virtual reality experience. The 74 pieces in the collection are available to visitors via virtual reality only. The owners of the collection decided against building a brick-and-mortar museum because they were having difficulty finding a location and the costs were prohibitive. Instead, they worked with Moyosa Media BV to produce a 3D, high resolution digital museum that showcases the collection of Dutch and Flemish masters (Moyosa Media, 2018).

Many extended reality applications are used to provide additional information about a museum’s collection. ARTlens (Pollalis, et al., 2018), for example, is a HoloLens-based augmented reality application that provides visitors with audio, visual, and textual information about an artifact the visitor approaches. The information is superimposed on the work. The user then airtaps to navigate through the materials.

Examples of immersive, interactive experiences include Studio Drift’s (2017) Concrete Storm. In this experience, viewers see concrete columns tilt and sway around them. The Tech Museum of Innovation in San Jose, California has an experience called Birdly. Visitors are given the experience of a bird in flight around the Manhattan skyline or above the clouds (Sylaiou, et al., 2018).

Extended reality applications have also been utilized in informal learning spaces such as museums, and studies have shown that learning capabilities of museum visitors were enhanced upon being subject to extended reality experiences. For example, utilizing AR in science museums (Yoon, et. al., 2012) and mathematics exhibitions (Sommerauer & Müller, 2014) resulted in enhanced learning capabilities for museum-goers, and incorporating AR onto art installations resulted in enhanced viewer's appreciation and learning of art works (Kolste & van Eck, 2011, tom Dieck, et. al., 2018).

Finally, extended reality experiences can be used to tell stories. The paper of Sylaiou and colleagues (2018) identifies at least two applications of this kind: Microsoft, Datacom in New Zealand and an indigenous group called the Ngati Whatua Orakei worked together to build a HoloLens experience that made the groups myths and stories more accessible to visitors. In Australia, another HoloLens experience was used to tell the story of Namande, a spirit that inhabits Kakadu, an Australian national park.

The Earthly Desires project draws inspiration from these examples, where we use augmented reality via the Microsoft HoloLens to provide visitors with additional information as well as to tell one of the stories the artist wanted depicted in the painting. Furthermore, note that the examples mentioned above were situated in developed countries. This project hopes to illustrate how the same technologies can be used in museums in the developing world.

3. Experience Design

3.1 Target Painting

In a catalog about Tapaya and his work, Recidoro (2015) describes Earthly Desires (see Figure 1) as a “kaleidoscope of historical and mythological images that represent man’s desires, principally for freedom or power.” The painting draws on Filipino mythology to convey these themes: a figure waiting for a liquid from a banana flower to drop into its mouth to give strength; the mirror image of an unjust ruler who grew horns because of his thoughtlessness; revolutionary Andres Bonifacio and his followers meeting in a secret cave, and so on. Figure 2 shows some of the various elements of interest that can be found in the painting.

Interestingly enough, our consultation with Rodel Tapaya offered another perspective. The artist offers the agimat, a talisman or amulet, as the starting point of his inspiration. From this starting point, the other visuals grew. By adding visual animations and audio narration, the experience encourages viewers to give the painting a more considered viewing and offers at least one of the artist’s perspective of the work.
3.2 Viewing Sequence

Following Tapaya’s advice, the thematic element in the painting, the *agimat*, was chosen to be the starting point for the experience. The viewer is prompted to gaze at the *agimat* to start the experience, where they are first introduced to what an *agimat* is. From there, an animation showing one of its tendrils extending guides the viewer to the underground cave where Bernardo Carpio, a mythological hero of great physical strength and the cause of earthquakes according to legend, is trapped by the power of an *agimat*.

The appearance of the snake-like creature with a cannon for a head evokes the battles fought by Philippine freedom fighters during the Spanish and American occupations. Andres Bonifacio, the man on the tree branch above the *agimat*, was one of the founders of the Katipunan, a Philippine revolutionary society that fought against Spanish colonial oppression. Like many other Katipuneros, he may also have carried an *agimat* with him.

Narration on the various powers of *agimat* continues as the viewer is guided by animations through other sections of the painting related to stories about objects of power and demonic trickery, such as the tale of the Leader with Horns, where a barber not only discovered that the town mayor was
actually a demon in disguise but also indirectly told the rest of the townsfolk via a rumor which turned into a children's song.

The experience continues by showing other creatures associated with protection in the painting and talking about people buying agimat from street vendors in Quiapo, a district in the city of Manila and home to Quiapo Church, where the feast of the Black Nazarene is held annually. The viewer’s gaze is then guided back to the area near the underground cave before revealing the Katipuneros near the underground cave, referring to the fact that both the story of Bernardo Carpio being trapped and the Katipunan’s secret meetings took place in the caves in the mountains of Montalban.

3.3 Design Decisions

To reduce both the risk of fatigue for viewers and the average waiting time if a queue forms, we initially set a maximum of 3 minutes for the experience's duration. Since many visitors to the Ateneo Art Gallery might not be familiar with the controls for augmented reality applications (such as gazes and gestures), the experience was designed to require almost zero interaction from the viewer except for the initial gaze to ensure the viewer was facing the right direction before starting the experience.

The whole experience was also designed while borrowing concepts from theater design with the guidance from one of our consultants, such as splitting the painting into "scenes", gradually fading scenes into view and fading scenes out from view, and using sound effects to drive the narrative, among others. He mentions that viewing a painting rich in various cultural references, such as Tapaya's *Earthly Desires*, can be an overwhelming experience, especially when viewed without any clues as to where to start looking. As such, Augmented Reality in this context helps greatly in viewing the painting since it is possible, to an extent, to use AR to dictate which elements are in view at any point in time, which can help guide the viewer to understand the painting better.

4. Implementation

4.1 Hardware and Software

We intended the experience to be viewed with the Microsoft Hololens (first generation), an AR head-mounted display (HMD) where the viewer wears the AR display like glasses. While it was possible to present the AR experience via a mobile device such as a smartphone, we opted for an HMD instead to not make viewers feel fatigued from holding up a mobile device for a prolonged period of time, allowing them to fully focus on viewing the experience.

We developed the AR experience using the Unity game engine (version 2019.2.13f1) paired with Microsoft Visual Studio 2019, which provides various tools to easily deploy apps to the Hololens. Since the viewer is required to gaze at the agimat in the painting to start the experience, we used the Vuforia AR Library plugin for Unity to enable the Hololens to detect whether the viewer gazed at the agimat to start the experience, as well as to establish an anchor point for the coordinate space where all the AR content will be positioned relative to. Due to potential errors in the registration process when tracking the marker, the coordinate space may not be aligned properly with the painting itself, thus minor adjustments need to be performed whenever the application is started. This can be improved by utilizing the World Anchor feature provided by the Hololens development kit, wherein adjustments to the position and orientation of the coordinate space can be stored and can be loaded every time the application opens. We plan to incorporate the World Anchor feature for the next iteration of the application.

4.2 Implementation Details

Once the viewer gazes at the agimat, the experience starts by slowly revealing a semi-transparent fog glass texture that covers the whole painting, with the intention of blurring the painting such that the animated elements in the experience pop up from the background due to contrast. We originally
intended to use a semi-transparent black texture for the overlay to make the painting appear darker. However, due to technical limitations of the Hololens where darker colors appear more transparent, we opted for a semi-transparent bright texture instead to blur the painting. The experience ends with the fog overlay slowly disappearing to gradually transition the viewer out of the experience, from the mixed reality world back to the real world.

The whole viewing sequence was divided into seven (7) parts or scenes, where each scene represents different sub-regions of the painting that tells a part of the overall narrative behind the painting. Figure 3 shows snapshots of the different scenes featured in the experience.

![Figure 3. Snapshots of the Progression from the Start to the End of the Experience.](image)

A scene consists of image pieces that are involved in the sub-region's narrative. The image pieces were extracted from the digital version of the painting, which was provided by the Ateneo Art Gallery, using GIMP (version 2.10.20), an open-source image editing software. The image pieces were extracted by cropping the image of the painting to the bounding rectangle describing the position
and size of the area of the image piece, wherein the position is relative to the upper-left corner of the painting. The bounding rectangles for each image piece were determined during the design phase. The cropped image pieces were then processed further by manually removing unnecessary parts from the image pieces (e.g., background color, foliage) via GIMP. The final textures for the image pieces were then imported to Unity and were positioned to match their original location in the painting. Given that the position and size of the image pieces’ bounding rectangle are expressed in pixel coordinates, a conversion scheme was necessary to convert them from pixel coordinate space (expressed in pixels) to the physical painting’s coordinate space (expressed in meters). Given the size of the painting in pixels (painting_size_pixels), the size of the painting in meters (painting_size_meters), the location and size of the image piece in pixels (piece_offset_pixels and piece_size_pixels respectively), we calculated the location and size of the image piece in physical coordinate space (piece_offset_meters and piece_size_meters respectively) using the following equation:

\[
\text{piece}\_\text{offset}\_\text{meters} = \frac{\text{piece}\_\text{offset}\_\text{pixels}}{\text{painting}\_\text{size}\_\text{pixels}} \times \text{painting}\_\text{size}\_\text{meters}
\]

\[
\text{piece}\_\text{size}\_\text{meters} = \frac{\text{piece}\_\text{size}\_\text{pixels}}{\text{painting}\_\text{size}\_\text{pixels}} \times \text{painting}\_\text{size}\_\text{meters}
\]

Each image piece is then animated individually by hand using Unity’s built-in animation system. Some of the image pieces were animated by modifying their corresponding transform properties (position, rotation, scale) over time, while some were animated by controlling what parts of the image piece are visible over time. For the latter, a custom shader that accepts a base texture image, a mask image, and a cutoff value was written to achieve the intended effect. The base texture image is the texture for the image piece itself, while the mask image is a grayscale image with a transparency channel that represents which parts of the image piece are visible based on the progression of the animation. For example, a pixel value of 0 (black) means that it is visible at the start of the animation, a pixel value of 1.0 means that it is visible at the end, and a pixel value of 0.5 means that it is visible halfway through the animation. Pixel values with an alpha (transparency) value of 0 are automatically discarded to enable the creation of mask images with complex shapes. Note that the size of the mask image does not necessarily have to be equal to the size of the base texture image, for all computations are done in the shader where texture coordinates are from 0 to 1, and in-between values are interpolated. Finally, the cutoff value ranges from 0.0 to 1.0, and controls how far into the animation the image piece currently is. Internally, the cutoff value controls which pixels are visible at a given point in time, such that areas in the mask image where the pixel value is greater than the cutoff value are discarded. For example, given a cutoff of 0.5, all areas in the mask image where the pixel value is higher than 0.5 will not be visible when rendering the texture of the image piece. The cutoff value was then animated over time through the built-in animation system to produce the effect of the image piece being slowly revealed over time. Figure 4 shows an example of the image mask used to show the agimat at the start of the experience, as well as the effects of different cutoff values. The center region of the mask is mostly black (0 pixel value), and smoothly transitions into white in a radial manner. All the mask images were all created by hand using GIMP as well.

![Figure 4. Example of an Image Piece with its Corresponding Mask, and the Effects of Different Cutoff Values.](image)

Once the individual image pieces were animated, they were then grouped into their corresponding scenes. Each scene also contains an audio track for the voice narration that describes what is happening in the scene, a set of audio tracks for accompanying sound effects, and a set of
animated image pieces. Particle systems were also utilized to enhance the visual animations in the scene. For example, during the scene where the freedom fighters were introduced, smoke particles were emitted from the tip of the cannon when the cannon fires a cannon ball. Particles were also displayed on the location of the agimat towards the end of the experience to further emphasize that the agimat is the central theme of the whole experience as well as the painting. The timings as to when the image pieces appear, animate, and disappear, when the particle systems are displayed, and when a specific audio track plays were all orchestrated using Unity's built-in timeline system. Each scene has their own timeline component and are called in succession by another script that manages the progression of the experience.

From start to finish, each scene is automatically played in succession with a two (2) second delay in between scenes. The scenes are played automatically to minimize the amount of interaction required from the viewer, and the delay between scenes serves as a way for the viewer to settle down after all the animations and the narration in the scene has finished, as well as to internalize the narrative presented in the scene. The choice for the duration of the delay was arbitrary, with the intention of making it long enough such that the viewer has a bit of time to reflect on the events that happened during the scene, but short enough as to not confuse the viewer whether the experience is already finished or if there is still another scene that follows. As the viewer progresses through the experience, previous scenes gradually fade out of view as to not overwhelm the viewer with all the visuals, and to avoid confusion on the side of the viewer as to where exactly to look. This design choice drew inspiration from theater design, where props used in a previous scene are subtly removed while the next scene is in view. The agimat, however, is constantly visible throughout the experience to emphasize that the agimat is the central theme of the experience and the painting. Finally, we also expected the viewer to look around the painting and its surroundings while viewing the experience, thus to make sure that the viewer does not miss the transition to the next scene, the application first checks whether the viewer is looking in the general direction of the painting before transitioning to the next scene. This was done by checking whether the angle between the view direction and the normal vector of the surface of the painting is less than or equal to 60 degrees.

Finally, during the design phase, there was also consideration of constructing the animations via a video editor software, and then presenting the whole experience by simply playing a series of video clips that are superimposed on top of the painting. We decided to adopt the current approach of constructing all the animations using Unity since it minimizes the amount of software needed to design the whole experience, and that constructing the animations and controlling the timing for the animations and the audio tracks inside Unity makes it easier to perform minor changes, and to test and see the changes instantly, instead of having to re-render and re-import the video clips every time a change has been made.

4.3 Narration and Audio Effects

To accompany the visuals, a narration of the scene accompanied the experience. In dramatic fashion, the narrator provided the viewer with a verbal explanation of the unfolding elements, with the narration delivered as if the narrator is a village elder telling the story to other members of the tribe. The narration begins with the explanation of what an agimat is and progresses to tell brief stories about Bernardo Carpio, Andres Bonifacio, and so on. Additional audio effects such as water drops, bird song, and wind provided the atmosphere to the experience and also act as cues to control pacing by filling in the delays between scenes.

5. Conclusions and Future Work

In conclusion, the project was successful in implementing the slow art experience. Feedback from our consultants and the artist himself was positive. They approved of the way the experience was designed and implemented, and they believe that the AR experience provided by the application will greatly help the art gallery visitors understand the cultural references presented in the painting better. They are also
convinced of the benefits that AR technology provides for enhancing the appreciation of paintings in general and are thrilled with the idea of incorporating AR technology to provide a similar experience for other paintings.

In the introduction and the review of literature, we mentioned that part of the goal of museums should be inclusivity and that the use of extended reality technologies was one way to achieve this goal. This project illustrates how indeed these technologies can be used even in developing countries, with local artists such as Rodel Tapaya.

Because of the COVID-19 pandemic and its associated community quarantines, we were unable to test the work. The next step, therefore, is to actually have museum visitors try the experience, ask them for their feedback to see whether the experience actually did provide them with a deeper appreciation for the painting, and modify the experience accordingly. While slow art is a widely encouraged method of enhancing visitor engagement, more research is needed to verify what benefits this approach brings (Chamberlain & Pepperell, 2020). Researchers have yet to ascertain the extent to which slow art enhances visual thinking strategies, art appreciation, and/or the museum experience in general.

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References


An Exploratory Study on PutraPacer as a Differentiated Assessment Tool for Learning

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Abstract The use of alternative assessment to curb the practice of standardized assessment in education in recent years has increased. Educators are challenged with the responsibility to address different needs of diverse learners and the dynamic nature of education that changes alongside rapid technology advancement. Realizing that changes in curriculum instruction and assessments are inevitable, educators attempt to improve their practices in alternative assessment. This includes emphasizing differentiation in assessment. Differentiated assessment makes it possible for educators to collect reliable data of students’ achievement which in turn will be used to plan better strategies in instruction that could address students’ different needs. However, to date, few papers have reported about differentiated assessments that have been carried out, especially in Malaysia. The aim of the present paper is to report on preliminary findings of the impact of PutraPacer as differentiated assessment tool on learning. This pilot study employs a qualitative research method with two undergraduate students and one lecturer as participants. The findings of this pilot study suggest that as a differentiated assessment tool, PutraPacer has supported differentiated learning and assessment among learners in the following ways: (i) reduces pressure in learning, and promotes individualised and self-directed learning experience, (ii) helps assessing students’ understanding, (iii) captures students’ different abilities, and (iv) provides platforms for students to justify responses.

Keywords: Alternative Assessment, Differentiated Assessment, Learners Diversity

1. Introduction

Differentiated assessment is one of the approaches to alternative assessment which advocates the practice of differentiation in assessment. Differentiation is “a philosophy that enables teachers to plan strategically in order to reach the needs of the diverse learners in classrooms today to achieve targeted standards” (Gregory & Chapman, 2013, p. 2). Differentiated assessment provides flexibility not only in the levels of knowledge acquisition, but also in skills development and types of assessments assumed by students (Varsavsky & Rayner, 2013). This attempt which addresses differences among learners is in line with the belief that learners are different in terms of background, characteristics, learning style, needs, preferences, interests, and abilities (Algozzine & Anderson, 2007; Kaur, Noman & Awang-Hashim, 2018; Lawrence-Brown, 2004; Tomlinson, 2001).

Education in the 21st century also sees a broadening spectrum of learners. This poses a challenge to educators where more appropriate teaching approaches are expected to meet the needs of diverse learners, and schools are proposed to be more reactive to cater to these diversities (Suprayogi, Valcke & Godwin, 2017; Tomlinson, 2015). Alongside these changes, Education 4.0, a term derived in response to the needs of Industrial Revolution 4.0 (IR 4.0) proved that changes in teaching methods are essential. Teaching and learning now are gradually transformed to more information-and technology-based, and leaning towards innovation (Anggraeini, 2018; Gulicheva, Lisin, Osipova & Khabdullin, 2017; Lawrence, Ching & Abdullah, 2019). One of the trends related to Education 4.0 discusses on how conventional platforms are no longer relevant and sufficient to assess students. Education 4.0 has transformed the traditional way of taking exams and it is about time that students are assessed differently (Fisk, 2017; Hariharasudan & Kot, 2018).
The Malaysian education system has paved the way for a better assessment through the latest reform of national assessment. Moving away from high-staked standardised examination, the Ministry of Education is now emphasizing assessment for learning, which is formative by nature. Teachers are also required to assess students using instruments other than written assignments and worksheets (Chin, Thien & Chew, 2019). Subsequently, this presents more opportunities for teachers to integrate differentiation in the classroom as “effective differentiation of instruction is inextricably bound to formative assessment” (Tomlinson & Moon, 2013, p.66). Previous research on alternative assessments in Malaysia show that formative assessments are already in practice. Among them are the use of learning tools such as rubrics, portfolios, online games, and concept maps (Alias & Osman, 2014; Ghani, Ibrahim, Yahaya & Surif, 2017; Swaran Singh & Abdul Samad, 2012). Other research focuses on instructional strategies like presentation, oral communication, and group work (Adnan, Mohd Sallem, Muda & Wan Abdullah, 2019; Chan & Sidhu, 2010).

However, based on the abovementioned research on alternative assessment, it is found that there is no generic, systematic and dedicated tools available yet for teachers and lecturers to employ differentiated assessment in mixed-ability classrooms in Malaysia. Therefore, this study attempts to study the impact of PutraPacer as a differentiated assessment tool for learning. PutraPacer is a web-based generic differentiated assessment tool for a mixed-ability classroom developed by researchers from Universiti Putra Malaysia (Md. Khambari, Wong & Mohd Norowi, 2019). This study is based on the following research question: (i) In what ways does PutraPacer support differentiated learning and differentiated assessment among learners?

2. Literature Review

Researchers have criticized the practice of standardized assessment due to its impracticality and disadvantages to students, parents and teachers (Nasri, Roslan, Sekuan, Bakar & Puteh, 2010; Zitlow & Kohn, 2001). Teaching methodology is affected by standardized assessment so much so that learning is focused on exam preparation practices (Wall, 1996). This unfortunately promotes rote memorization among students who subsequently becomes surface learners with weak reasoning power (Newstead & Findlay, 1997; Black & Wiliam, 1998). With limited format and simpler forms of questions, standardized assessment hinders students’ application of higher levels of knowledge. Moreover, it is also challenging for them to truly demonstrate what they have learned, the learning process involved and where the learning happened (Letina, 2015). According to Tomlinson, standardized assessment “are not designed to address variance in readiness, interest, or learning profile” (Tomlinson & Moon, 2013, p.76). This shows that standardized assessment is incapable to cater to learners’ diverse and individual needs (Noman & Kaur, 2014; Tomlinson, 2015).

McNamara (2001) defines alternative assessment as a step to do away with standardized assessment by replacing it with a more refined performance-based assessment. Alternative assessment supports higher-order thinking and problem-solving abilities among students which is essential in developing skills needed in the 21st century (Burke, 2005; Alias & Osman, 2015). Janisch, Liu & Akrofi (2007) assert that alternative assessment has the potential to evoke students’ autonomy in learning. This notion is further supported by Gozuyesil and Tanriseven (2017) who believe that through alternative assessment, students can explore their own ideas to self-evaluate their own learning styles. Hence, flexible, and meaningful experiences are achieved. Alternative assessment has made it possible for teachers to get information about students’ strengths and weaknesses because they are manifested over time (Swaran Singh & Abdul Samad, 2012). Likewise, Mohtar (2010) agrees that through alternative assessment, information on student progress and achievement are more valid and reliable. Therefore, it is imperative for educators to have good knowledge about alternative assessment methods and the fundamental theory underlying it (Janisch et al. 2007).

Kingore (2004) points out that differentiation is implemented in the classroom on the ground that students have different background knowledge and ability. Instead of casting students in the same mould as if they are alike, teachers can practise differentiation by responding accordingly to the needs of their students based on their different learning profiles, interests, and readiness. In order to reach out
to diverse learners, Noman and Kaur (2014) imply that differentiation in assessment is as important as differentiation in instruction especially in terms of informed learning. As differentiated assessment is normally formative in nature, authentic data of students’ achievement can be collected and used by teachers to plan better strategies in instruction (Koshy, 2013). Besides learning flexibility and types of measurement undertaken by students, Varsavsky and Rayner (2013) claim that through differentiated assessment, students also have the autonomy of choosing how to develop their skills based on their talents and learning styles. Apparently, this view is relevant to the idea that intelligence is not a fixed trait and all students learn at their own pace (Presseisen, Smey-Richman & Beyer, 1992).

3. Theoretical Framework

Vygotsky’s sociocultural theory is fundamental in foregrounding the concept of differentiation. This theory proposes that teachers will be able to take advantage of students’ ability and give them individual opportunity to participate and learn based on certain social and cultural contexts (Kaur, Noman & Awang-Hashim, 2018; Tomlinson, 1999). Vygotsky suggests that learning happens within the Zone of Proximal Development (ZPD). Within the ZPD, learning is also believed to happen “on a novice-to-expert continuum that builds over time rather than being constrained by a specific set of grade-level standards” (Tomlinson & Moon, 2013, p.72). In ZPD, scaffolding supports learning, and this enables a student to accomplish tasks that are initially beyond his or her capability (Wood, Bruner & Ross, 1976). Scaffolding also helps develop students’ abilities by increasing the complexity levels of a task (Shabani, Khatib & Ebadi, 2010) and reveal students’ hidden potential (Ajideh & Nourdad, 2012).

According to Crim, Kennedy, and Thornton (2013), Tomlinson’s (1999) model of differentiation highlights the importance of identifying and creating space for multiple intelligence in order to stimulate students’ individual interests and learning profiles. Gardner’s (1983) multiple intelligence theory asserts that people process the world and prove their strengths in multiple ways and the construct of intelligence can be achieved with a non-conventional method (Crim et al., 2013). Gardner (1999) identified eight dimensions of intelligence namely bodily kinaesthetic intelligence, linguistic intelligence, logical-mathematical intelligence, musical intelligence, naturalistic intelligence, interpersonal intelligence, intrapersonal intelligence, and visual spatial intelligence. In the context of assessment, Gardner (1992) strongly believes that assessments that fail to address vast differences among individuals are outdated and teacher training should focus on individual differences.

4. PutraPacer

PutraPacer is a systematic web-based tool designed and developed by a group of researchers from the Faculty of Educational Studies and the Faculty of Computer Science and Information Technology of Universiti Putra Malaysia (UPM). PutraPacer provides tiered levels of assessments that are appropriate for students with different learning abilities, interests, and level of preparedness. PutraPacer incorporates the elements of differentiated instruction, where students can learn according to their abilities and given the opportunities to get appropriate education in general education classrooms (Lawrence-Brown, 2004). By using PutraPacer, instructors could create tiered levels of assessments according to level of difficulties. For example, easy, medium, and hard. This function helps low to middle ability learners to engage with their learning instead of memorizing the information which may ease the pressure on learning (Llewellyn, 2003). Meanwhile, advanced learners will have the opportunities to engage in a more challenging task. According to Dikli (2003), this will provide a much accurate insight of students’ skills and abilities and reflects instructors’ pedagogical strategies.

PutraPacer also enables students to demonstrate what they have learned, according to their ability. This feature is deemed useful to be embedded in PutraPacer as alternative assessment promotes students’ comprehension and accomplishment rather than testing students on what they remember (Caliskan & Kasikci, 2010). Instructors could create questions that prompts students to present their answer in various forms like audio recording, video recording or mind maps. The development and
employment of PutraPacer will increase awareness of alternative assessment among instructors in UPM. Thus, supporting UPM’s effort to promote alternative assessment practice and the implementation of smart campus (Md. Khambari, Wong & Mohd Norowi, 2019).

5. Methodology

As this study is exploratory in nature and attempts to gain an initial insight on the first prototype of PutraPacer, a qualitative instrumental case study approach was employed. This was done to ensure that an in-depth exploration on participants’ perception can be carried out at a micro-level (Yin, 2014). Furthermore, this pilot study was bounded within instructors and students at a faculty in UPM, and carried out within a certain time frame, which warrants for an instrumental case study as suggested by Merriam and Tisdell (2016).

In this study, a course instructor who volunteered to employ PutraPacer and two of her undergraduate students were the participants. The course instructor is an expert in Human-Computer Interaction and has more than 5 years of teaching experience. Their participation is meaningful to this research in such ways that they gave an insight on how can the tool support differentiated learning and differentiated assessment, and indirectly, help the researchers to identify bugs and fixes that can be done before PutraPacer can be carried out to a larger sample group for further data collection. Prior to data collection, the course instructor participant was recruited through a series of intensive workshop trainings on how to utilize PutraPacer for differentiated assessment. In terms of data collection, a non-participatory observation was conducted during a revision assessment session carried out by the course instructor in a multimedia laboratory. The observation focused on how students responded to assessment questions on PutraPacer. After the session was over, the course instructor and two volunteering students were interviewed in separate sessions to elicit their feedback on their experience with the tool. Each interview lasted for about 40 minutes.

A constant comparative method was employed for data analysis to maintain both the emic perspectives of the participants, and the etic perspectives of the theory and researchers (Charmaz, 2014). In the First Cycle, interview transcripts and field notes from the observations were read and re-read to increase the researchers’ familiarity with the data. The data were then coded using Descriptive Coding and In Vivo Coding with memos (Saldaña, 2009). Among codes derived from Descriptive Coding are ‘test ability’, ‘self-correction’, and ‘demonstrate understanding’. Meanwhile, through In Vivo Coding, codes such as ‘more individual’, ‘relax and happy’, and ‘own pace’ were retrieved from the data. Further, using Pattern Coding with memos-on-memos in the Second Cycle, major themes from the data were developed. Data that emerged from these cycles were then sorted and themed accordingly (Saldaña, 2009). Major categories resulted from the Second Cycle are ‘positive emotions’, ‘individual experience’, ‘demonstrate understanding’, ‘scaffolding’, ‘self-directed learning’, ‘different abilities’, and ‘multiple learning styles’. After reviewing the major categories, the data analysis were finalized by regrouping the categories and form another coherent themes which are discussed in the following section.

6. Findings and discussions

Data analysis of the impact of PutraPacer as a differentiated assessment tool on learning revealed the following themes: 1) PutraPacer reduces pressure in learning, and promotes individualised and self-directed learning experience, 2) PutraPacer helps assessing students’ understanding, 3) PutraPacer captures students’ different abilities, and 4) PutraPacer provides platforms for students to justify responses. To facilitate the data presentation and safeguard the participants at the same time,
Both students, namely Ali and Rina, and their course instructor, Nor, expressed that the use of PutraPacer reduced the pressure in learning, especially when it is used for assessment. While Ali and Rina both showed positive feedback based on their experience answering quiz questions on PutraPacer, Nor showed excitement for learning to use PutraPacer to conduct a quiz for the first time. Nor also could see that her students were relaxed and happy during the quiz mainly because their scores would not influence their Cumulative Grade Points Average (CGPA).

It felt good. It felt very natural and intuitive for the most part (Ali).

I actually really enjoyed the experience because, well to compare with my previous experience with PutraBlast quiz, I prefer PutraPacer more because it’s easier, it’s very user friendly and I really like the design of it (Rina).

I felt excited because it is something new...So, when I tell them there will be no marks, they won’t be assessed on this, I think students tend to be more relaxed and happy when they are approached to do the questions or the quizzes (Nor).

Their marks or their scores and CGPA is not on the line. So, learning is more than just trying to get the highest scores, but learning is trying to improve one’s understanding or comprehension on the subject (Nor).

Based on observation, the researcher agrees that the quiz session was conducted in a relaxed and somewhat casual manner. Most questions posed by students during the quiz were about the technical settings of PutraPacer. The session went about smoothly. During the discussion that happened after all students submitted the answers, it was interesting to see students joking around saying that the quiz was like playing an online game because they need to achieve a certain score to be able to proceed to a higher level. This finding is in congruent with Hashemian (2011) who demonstrates that without pressure, students are more aware of the learning process, feel contented with their improvement and will attempt to continue the process and sometimes leads to creativity. Isen, Daubman and Nowicki (1987) also suggest that positive affects facilitate in creative problem-solving which is one of the skills essential for the 21st century learners (Burke, 2005; Alias & Osman, 2015).

As a first-year undergraduate student, Rina who had experience doing assessments in written and digital forms before, believed that PutraPacer is different in a way that it offers individualised learning experience. Nor who has about 17 years of teaching experience also thinks likewise.

...it’s more individual and you can test your ability to know how much you know about the subject (Rina).

So, I think that is how PutraPacer may have impacted students’ learning, in a sense that they understand that it’s their own pace, it is a very individualistic experience and they are not being constantly judged or assessed (Nor).

Ali (2015) reported that one of the objectives of differentiated assessment is to individualised learning. Individualised learning enables students to complete a task given at their own pace and move further in their learning by attempting to do better than their personal current level of ability (Ajideh & Nourdad, 2012). Based on the researcher’s experience as a teacher, these attributes helps to diminish students’ need to compete with fellow classmates where oftentimes students complete a task for the sake of getting ahead of their classmates without understanding what the real learning objectives of the
Rina and Nor also find that students can take initiative to learn from their mistakes and relearn, without the help of others. This could be made possible by checking the correct answers which are displayed right after getting the results. Students can also retake the same quiz and improve their answers at every attempt they made.

*It challenges you to correct yourself and make you remember what your mistakes before and learn from it (Rina).*

*If they get it wrong, they will have the chance to relearn or fix whatever is wrong (Nor)*.

Some students manage to answer all the questions sooner than their other friends. The researcher saw that these students took the opportunity to check the correct answers which were displayed automatically after they have submitted the quiz. A few students managed to detect discrepancies in the given answers. This has led to a further discussion with the lecturer. According to Li and Burke (2010), “adults learn best when they are actively engaged in the learning process and self-direct their own learning goals and activities” (p.1). The researcher believes that self-directed learning is a trait of an autonomous learner. As a differentiated assessment tool, PutraPacer therefore has the potential to support students to become autonomous learners, in line with the study done by Janisch et al. (2007).

**6.2 Assessment of student’s understanding**

Rina and Nor agree that PutraPacer helps assessing student’s understanding on topic or a subject. Nor believes that information about students’ level of understanding can help identify issues where students are struggling with.

*... you can test your ability to know how much you know about the subject (Rina).*

*So, I think that’s one way that may improve or impact me as an instructor, to be able to understand where students stand or their level of understanding, because right now it’s really hard. Right now, only after a test that you can tell this thing...these students are struggling, they are failing Test 1. By that time, it will be a bit too late. So, I think with PutraPacer, you can detect this issue earlier on (Nor).*

By getting information on students’ level of understanding, a teacher could reassess his or her method of teaching. Consequently, the teacher can improve or make adjustment to the teaching method so that the learning outcomes will be aligned with students’ needs and according to their level of understanding. Findings in studies by (Swaran Singh & Abdul Samad, 2012) and Mohtar (2010) agree that reliable information of student’s progress including their weaknesses and strengths, can be retrieved through alternative assessments.

**6.3 Captures students’ different abilities**

PutraPacer enables students to be aware of their own ability. The quiz conducted in this pilot study is taxonomy-based which allocated three levels of difficulties. Ali and Rina were aware of this key feature and its purpose. The course instructor finds that by knowing each of the student’s ability, she could learn the demography of her class especially in terms of learning abilities.

*From my thoughts, it seems to allow different types of people to be able to engage with the same quiz whereas a usual quiz, we have both hard and easy questions at once*
which isn’t really suited for people who aren’t as advance (Ali).

We can know which level we are at (Rina).

...lecturers can set different levels based on the difficulty of the questions. I think that’s how it will be able to show the different abilities that the students have... the lecturers can see how many of their students can understand and how vastly distributed the learning abilities are among the students (Nor).

PutraPacer could capture students’ different abilities by deliberately setting a quiz or a test to taxonomy based. As claimed by Varsavsky and Rayner (2013), by offering flexibility in levels of knowledge attainment, differentiated assessment could address differences among students. Based on each student’s different ability, teachers can plan a lesson or an assessment which offers the students the opportunity to show what they know, what they understand and what they can do. Tomlinson and Moon (2013) defined this method as ‘differentiation through product’.

6.4 Provides a platform for students to justify responses

In PutraPacer, the attachment function added at each answer box allows students to attach their justification for their responses, in the form of text, audio, and visuals. Nor figured that through this function, learning can be more interactive for the students especially when conveying their opinion through their answer. This is exemplified in the excerpt below:

... students can provide audio or video input to justify their work, or actually defend their answer or support their answer...they (students) also understand that learning is not just one way coming from the lecturer and they have to answer and that’s all the interaction that they get, but it can be more interaction where they can voice out their opinions or they can maybe rectify something which they feel is not right (Nor).

However, this feature was not implemented in the first round of pilot test due to time constraint on the course instructor’s end. Nevertheless, she strongly believed that one of PutraPacer distinctive features is providing a platform for students to be more expressive on their opinion, and she was looking forward to making good use of this feature in the future. This feature could provide the best opportunity for each student to demonstrate his or her learning. This is consistent with Ali (2015) who suggested that differentiated assessment should take multiple intelligence into consideration as well as students’ learning and thinking styles.

7. Conclusion

Overall, the findings from the pilot study suggested that PutraPacer has supported differentiated learning and differentiated assessment in some meaningful ways. Although this study is small scaled, it offers meaningful findings to help improve the tool and shed new light on the implementation of a web-based differentiated assessment in education in Malaysia. More conclusive studies that are quantitative or qualitative in nature are needed to establish PutraPacer as a practical and operational differentiated assessment tool that can be used across all levels of education. It is also important to point out that based on the preliminary findings, the participants feedbacks are noticeably positive. This could be due to the excitement of using PutraPacer for assessment for the first time. The researcher believes that there is a need to think of ways to preserve the novelty of this tool so that users will be drawn to keep using PutraPacer and reap its benefits to enhance their learning experience as well as practice of alternative
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References


Analysis of Income Classification and Expenditure Patterns among Filipino Households Using Data Mining Applications

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Abstract: Data Mining is a knowledge discovery process that includes extracting hidden, previously unknown, and potentially useful information from datasets. The analysis of its outcomes can be used for future planning and development perspectives. This paper explores the income and expenditure behavior to determine patterns and associations that describe Filipino households. Drawing from the Family Income and Expenditure Survey of 2015 (FIES 2015) by the Philippine Statistics Authority, a descriptive profile of income and expenditure, a predictive model of income from household characteristics and prescription of important aspects which can be considered by the government in developing policies that may elevate the quality of life of Filipino families, were done. Results showed that the majority of Filipino households are in the first two lower-income brackets and generate negative to no savings at all. For expenditures, majority of the groups spend on Food and Resto. Moreover, the most significant variables that drive the capacity to generate income are education and employment. It is suggested that the government should strengthen its programs in the following areas.

Keywords: Data Mining, Income Determinants, Expenditure Behavior, Weka, FIES 2015

1. Introduction

The Philippine government aims to join other developing countries in increasing income groups from lower-middle income to upper-middle income status. This goal is reflected in its long-term goal dubbed as “AmBisyon Natin 2040” which aspires a stable and comfortable life for Filipinos (NEDA, 2016). One way to achieve these targets is understanding the trajectory of income versus expenditures. While income is a representation of a quality life since it capacitates people to avail basic needs (Villejo, Enriquez, Melendres, Tan, & Cayton, 2014), consumer expenditure patterns depict economic trends in the household sector (Leonard, 2018). As such, income units and spending patterns has become vital that it is routinely tracked by the government through a nationwide household survey called the Family Income and Spending Survey or FIES (Cruz, 2013).

FIES aims to provide necessary information to the government policymakers on family income and expenditures in the Philippines. Since spending pattern changes through time, expenditure components of the FIES are also revised to include new items commonly consumed by Filipinos during the period covered (Ericita & Fabian, 2009). While purchasing decisions are made at the household level and are particularly behavior-driven, appropriate interventions require an understanding of the dynamics of household activities and their associated economic impacts (Froemelt, Dürrrenmatt, & Hellweg, 2018). Along this line, households are able to make better decisions in their resource allocation by understanding their patterns of consumption hence, becoming better consumers (Babin & Harris, 2016). This study aims to explore the FIES 2015 data set by applying data mining techniques using Weka in order to analyze factors driving income from household characteristics and expenditure patterns of Filipino households thereby understanding significant variability of their spending behavior.
within investigated household types (Hsieh & Chu, 2009). Through data analytics perspective, this study aims to contribute to the investigation of relationships and associations among different variables provided in the FIES 2015 and to provide valuable insights for policymakers when enacting and improving policies related to poverty alleviation.

2. Overview of Related Literature

2.1 Consumer Behavior Pattern

Consumer behavior in its holistic form is a fascinating phenomenon, and it is more so when perceived from the viewpoint of the associated heterogeneity among the consumer group (Gbadamosi, 2018). These groups are often segmented according to demography such as age, race, religion, gender, family size, ethnicity, income, and education (Gbadamosi, 2018; Hsieh & Chu, 2009). Each group have different consumer behavior that often consists mainly of consumption-relevant sequences. Their decisions are sometimes straightforward, involving few resources, and occasionally dynamic, involving large amounts of resources (Babin & Harris, 2016; Mais, 2019). As consumers make decisions, they set up a chain of consequences that change their lives, the lives of those around them, and the lives of people they do not even know (Babin & Harris, 2016). The individual household determines the optimum distribution of its income, physical, and time resources. This allocation can be based on whether the household jointly produces income, the number of household members, and their lifestyle (HOA, 2005). Consumers who understand their patterns of consumption can make better decisions concerning how they allocate resources to become better consumers (Agag & El-masry, 2016; Babin & Harris, 2016). When the allocation of resources is improved, it is considered smart spending. Spending smart is a specific philosophy for achieving financial security without depriving oneself (Karp, 2008). Smart spending is the overall strategy and specific ways to reduce spending without deprivation thus, achieving financial security in the long run (Karp, 2008, 2009).

3. Methodology

The study employed the concepts of analytic techniques outlined by Gartner (Gartner, 2016) to create the operational framework, as shown in Figure 1. Data preparation is done before the actual analysis of data. Descriptive analytics phase examines data or content to determine what has happened or what is happening in the context where the data belongs. In this paper, it is done by descriptively identifying different patterns and association from the data in relation to family income and its expenditures. Predictive analytics phase examines the data or content to know what is going to or likely to happen. In this paper, regression analysis is performed in order to forecast income and expenses. The last phase is prescriptive analytics where it examines data or content to determine what should be done or what can be done to make something happen. In this paper, prescription is done to recommend a course of action related to the analysis made on the data.

![Figure 1. Operational Framework](image)

The primary data source used in the study is the Family Income and Expenditure Survey (FIES) in
2015. According to the Philippine Statistics Authority (PSA), the data includes level of consumption by item of expenditure and its sources. It also presents spending patterns of families and other related information such as number of family member, occupation, age, educational attainment of household head and other family and housing characteristics. In line with the objective of this paper, data associated with income and expenses is given attention. Since family income is of numeric data type by nature, a multiple linear regression is deemed fit to determine significant variables that drive family income using more than one other variables. These attributes were considered because they represent the household characteristics through the household heads’ descriptions and family compositions.

The classification of income classes of Filipino households was adopted from Albert et al. (2018) which outlines the indicative range of family monthly incomes, for the a family of five, based on 2017 prices. The income clusters are shown in table 1.

Table 1. Indicative range of monthly family incomes (Albert et al., 2018)

<table>
<thead>
<tr>
<th>Income Cluster</th>
<th>Indicative Range of Monthly Family Incomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor</td>
<td>Less than PHP 9,520</td>
</tr>
<tr>
<td>Low income but not poor</td>
<td>Between PHP 9,520 to PHP 19,040</td>
</tr>
<tr>
<td>Lower middle income</td>
<td>Between PHP 19,040 to PHP 38,080</td>
</tr>
<tr>
<td>Middle middle income</td>
<td>Between PHP 38,080 to PHP 66,640</td>
</tr>
<tr>
<td>Upper middle income</td>
<td>Between PHP 66,640 to PHP 114,240</td>
</tr>
<tr>
<td>Upper income but not rich</td>
<td>Between PHP 114,240 to PHP 190,400</td>
</tr>
<tr>
<td>Rich</td>
<td>At least PHP 190,400</td>
</tr>
</tbody>
</table>

Moreover, the software Microsoft Excel was used for data cleaning and formatting instances of the data. The file was converted to comma separated values (.csv) format and was loaded to Sublime Text Editor to be converted to an attribute relation file format (.arff). The ARFF file is then loaded to Weka for data analysis.

4. Results and Discussions

4.1 Descriptive

4.1.1 Profile of Income Classes

The data from the FIES 2015 survey (Philippine Statistics Authority, 2015) was analyzed using descriptive analytical techniques to show the income and expenditure patterns of Filipinos households. There is a total of 41,544 respondents; most of which belong to Cluster 2 bracket. The minimum, maximum, and mean income for each cluster is presented in Table 2.

Table 2. Income Clusters generated for Average Annual of Households

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11285</td>
<td>114240</td>
<td>80131.74</td>
<td>12255</td>
</tr>
<tr>
<td>2</td>
<td>114242</td>
<td>228478</td>
<td>161498.80</td>
<td>15017</td>
</tr>
<tr>
<td>3</td>
<td>228493</td>
<td>456842</td>
<td>317933.20</td>
<td>9306</td>
</tr>
<tr>
<td>4</td>
<td>456972</td>
<td>799391</td>
<td>585997.40</td>
<td>3508</td>
</tr>
<tr>
<td>5</td>
<td>800214</td>
<td>1366996</td>
<td>1001564</td>
<td>1100</td>
</tr>
<tr>
<td>6</td>
<td>1370984</td>
<td>2275298</td>
<td>1688504</td>
<td>272</td>
</tr>
<tr>
<td>7</td>
<td>2292000</td>
<td>11815988</td>
<td>3509863</td>
<td>86</td>
</tr>
</tbody>
</table>

For the type of household among Filipinos, majority of the families across all clusters belong to a single family depicted in Table 3, which consists of more than 50% across each cluster's total population. There are almost none or no percentage of families composed of 2 or more non-relative members in the
It is also worth reflecting that most of the Filipino households' sources of income came from salaries and wages among clusters 1 to 6. As seen also in table 4, the secondary source of income for all clusters except cluster 2 is from other sources of earnings, while cluster 2 is from entrepreneurial activities. For the rich group bracket, their primary source of income came first on entrepreneurial activity (44.19%), followed by other sources of revenue (34.88%). This is because families belonging to this group are entrepreneurs and business-oriented (Ulep & Dela Cruz, 2015).

4.1.2 Profile of Expenses

For the average income and expenditure styles, Table 5 showed the Filipino’s earning and spending pattern across income clusters. Based on the identified and accumulated expenditures, most Filipinos in the Cluster 1 and 2 depict a negative savings amount.

Savings are computed from the average income deducted by average expenditure. This relationship is known as the consumption schedule (Leonard, 2018). Interestingly, the first two clusters' savings values are negative. This is attributed to Filipinos on these clusters having no proper financial

<table>
<thead>
<tr>
<th>Household Types</th>
<th>Single Family</th>
<th>Extended Family</th>
<th>Has 2 or more nonrelated members</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>1</td>
<td>9827</td>
<td>80.19</td>
<td>2393</td>
<td>19.53</td>
</tr>
<tr>
<td>2</td>
<td>10596</td>
<td>70.56</td>
<td>4379</td>
<td>29.16</td>
</tr>
<tr>
<td>3</td>
<td>5391</td>
<td>57.93</td>
<td>3868</td>
<td>41.56</td>
</tr>
<tr>
<td>4</td>
<td>1865</td>
<td>53.16</td>
<td>1614</td>
<td>46.01</td>
</tr>
<tr>
<td>5</td>
<td>573</td>
<td>52.09</td>
<td>518</td>
<td>47.09</td>
</tr>
<tr>
<td>6</td>
<td>146</td>
<td>53.68</td>
<td>121</td>
<td>44.49</td>
</tr>
<tr>
<td>7</td>
<td>47</td>
<td>54.65</td>
<td>39</td>
<td>45.35</td>
</tr>
<tr>
<td>Total</td>
<td>28445</td>
<td>68.47</td>
<td>12932</td>
<td>31.13</td>
</tr>
</tbody>
</table>

It is also worth reflecting that most of the Filipino households' sources of income came from salaries and wages among clusters 1 to 6. As seen also in table 4, the secondary source of income for all clusters except cluster 2 is from other sources of earnings, while cluster 2 is from entrepreneurial activities. For the rich group bracket, their primary source of income came first on entrepreneurial activity (44.19%), followed by other sources of revenue (34.88%). This is because families belonging to this group are entrepreneurs and business-oriented (Ulep & Dela Cruz, 2015).
management skills where they may not know how to handle a hard-earned money and just spend it spontaneously (Hunter & Adal, 2017; Te, Japson, & Velecina, 2017). In effect, money is spent even when there is not enough income to cover it. Spending among Filipinos falls on the aggregated expenditures. From Table 6, it is worth noting that Clusters 1, 2, and 3 spent most on Food & Resto followed by expenses on House, rent and utilities including water and electricity. This means that food occupies almost half of the total income of households belonging to these clusters.

Table 6. Distribution of Expenditures Across Income Clusters

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Food &amp; Resto</th>
<th>House, Water &amp; Rental Values</th>
<th>Clothing &amp; Footwear</th>
<th>Education</th>
<th>Transportation &amp; Communication</th>
<th>Miscellaneous Goods &amp; Services</th>
<th>Tobacco &amp; Alcohol</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>52%</td>
<td>21%</td>
<td>02%</td>
<td>01%</td>
<td>04%</td>
<td>18%</td>
<td>02%</td>
</tr>
<tr>
<td>2</td>
<td>48%</td>
<td>23%</td>
<td>02%</td>
<td>02%</td>
<td>06%</td>
<td>17%</td>
<td>02%</td>
</tr>
<tr>
<td>3</td>
<td>40%</td>
<td>28%</td>
<td>02%</td>
<td>03%</td>
<td>08%</td>
<td>17%</td>
<td>02%</td>
</tr>
<tr>
<td>4</td>
<td>32%</td>
<td>31%</td>
<td>03%</td>
<td>05%</td>
<td>09%</td>
<td>19%</td>
<td>01%</td>
</tr>
<tr>
<td>5</td>
<td>25%</td>
<td>35%</td>
<td>03%</td>
<td>06%</td>
<td>10%</td>
<td>20%</td>
<td>01%</td>
</tr>
<tr>
<td>6</td>
<td>22%</td>
<td>37%</td>
<td>03%</td>
<td>07%</td>
<td>12%</td>
<td>19%</td>
<td>00%</td>
</tr>
<tr>
<td>7</td>
<td>16%</td>
<td>45%</td>
<td>03%</td>
<td>05%</td>
<td>11%</td>
<td>20%</td>
<td>00%</td>
</tr>
</tbody>
</table>

For Clusters 5, 6 and 7 they spent inversely from the previous clusters where House, Water and rental values come first before Food and Resto. In comparison, for a developed country such as Singapore, majority of their income is also spent on housing and housing related expenditures accounting for 28.9% of their monthly expense (Singapore, 2019). Interestingly, Cluster 7 spent second-most of their income to miscellaneous goods and services which consists of medical care, special occasion expenses and even crop farming spending while Cluster 6 spent the most on transportation and communication.

4.1.3 Associations

The amenities inside every household were also determined from appliances, transportation medium and personal devices. These data points were extracted in order to present additional household characteristic patterns that may have an influence on family’s expenses and convenience brought by their income. To reveal possible interesting relationships, an association rule mining was done through Apriori algorithm in Weka.

Apriori algorithm is a widely used and important algorithm for association rule mining. The two major steps executed by Apriori algorithm include frequent itemset generation to find all itemset that satisfies the minimum support (minSup) threshold and association rule generation to extract all high confidence rules from the generated frequent itemset. Setting the minimum metric (minMetric) to 0.90 and number of rules to 10 (numRules), the following rules and associations with the corresponding confidence level are shown in Table 7.

Table 7. Top 10 Best Rules using Apriori Algorithm in Weka

<table>
<thead>
<tr>
<th>Best Rules Found (number of instances)</th>
<th>Confidence Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>washing machine (13,060) ⇒ television (12,739)</td>
<td>0.98</td>
</tr>
<tr>
<td>refrigerator &amp; cellphone (14,815) ⇒ television (14,427)</td>
<td>0.97</td>
</tr>
<tr>
<td>CD/VCD/DVD &amp; cellphone (15,988) ⇒ television (15,537)</td>
<td>0.97</td>
</tr>
<tr>
<td>refrigerator (15,554) ⇒ television (15,109)</td>
<td>0.97</td>
</tr>
<tr>
<td>CD/VCD/DVD (16,923) ⇒ television (16,401)</td>
<td>0.97</td>
</tr>
<tr>
<td>washing machine (13,060) ⇒ cellphone (12,559)</td>
<td>0.96</td>
</tr>
<tr>
<td>television &amp; refrigerator (15,109) ⇒ cellphone (14,472)</td>
<td>0.95</td>
</tr>
<tr>
<td>refrigerator (15,554) ⇒ cellphone (14,815)</td>
<td>0.95</td>
</tr>
<tr>
<td>television &amp; CD/VCD/DVD (16,401) ⇒ cellphone (15,537)</td>
<td>0.95</td>
</tr>
<tr>
<td>CD/VCD/DVD (16,923) ⇒ cellphone (15,988)</td>
<td>0.94</td>
</tr>
</tbody>
</table>
It can be gleaned from Table 7 that, with 98% confidence level, most households who own washing machine also own television. The following associations were also towards ownership of television and cellular phones. The association rules generated were reflective of the top five most visible household convenience in Filipino homes. Based on the data, cellular phones dominate Filipino homes with maximum of 10 units in a household. Television comes in second with a maximum of 6 units in a household. It is then followed by CD/VCD/DVD players and refrigerator or freezer with maximum of 5 units per every household. Lastly, washing machine comes in with a maximum of 3 units in a given household. Other convenience considered from the data include personal computers, motorcycle or tricycle, stereo set, stove with oven or gas range and air conditioning units. The bottom three, considered as the least visible among all households across income brackets include car, jeep or van, landline or wireless telephones and motorized banca.

4.2 Predictive

4.2.1 Income and Expense Projection

The prediction of an unconditional welfare distribution, such as income and expenditure is deemed important particularly for inequality, development studies and poverty (Dai, Sperlich, & Zucchini, 2012). Both income and expense data were forecasted using time series and linear regression as the base learner configuration in Weka. The historical data from year 2000 up to year 2012 for income and expenditures were culled out from reports in the Philippine Statistics Authority website as the working data set is only for year 2015. Not considering other economic factors that may affect income and expenses such as inflation and prices, the time series projected the next five units and a yearly periodicity and timestamp. Taken together, the estimated annual amounts of income and expenses are presented in Table 8.

Table 8. Projected Annual Income and Expenditure

<table>
<thead>
<tr>
<th>Year</th>
<th>Projected Average Annual Income</th>
<th>Projected Average Annual Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>144,039</td>
<td>118,002</td>
</tr>
<tr>
<td>2003</td>
<td>148,000</td>
<td>124,000</td>
</tr>
<tr>
<td>2006</td>
<td>173,000</td>
<td>147,000</td>
</tr>
<tr>
<td>2009</td>
<td>206,000</td>
<td>176,000</td>
</tr>
<tr>
<td>2012</td>
<td>235,000</td>
<td>193,000</td>
</tr>
<tr>
<td>2015</td>
<td>267,000</td>
<td>215,000</td>
</tr>
<tr>
<td>2018*</td>
<td>297,607.2924*</td>
<td>239,327.9861*</td>
</tr>
<tr>
<td>2021*</td>
<td>328000.0505*</td>
<td>262741.5342*</td>
</tr>
<tr>
<td>2024*</td>
<td>358494.4463*</td>
<td>285953.8305*</td>
</tr>
<tr>
<td>2027*</td>
<td>389088.4699*</td>
<td>309121.8347*</td>
</tr>
<tr>
<td>2030*</td>
<td>419743.3629*</td>
<td>332280.0911*</td>
</tr>
</tbody>
</table>

From Table 8, it can be deduced that there is a direct relationship where income increases, expenditure is expected to increase as well. This consumption schedule suggests that where there is more money or hopes of income, the more goods are purchased by consumers (Leonard, 2018). However, as this projection results represent data across multiple income brackets, those belonging to lower clusters may experience having to spend on expenditures even when there is not enough income to cover them. This relationship between expenditures and savings which may stem from behavioral and structural reasons may also be explored in further studies.

4.2.2 Determinants of Income Using Multiple Regression Analysis.

A multiple regression analysis is performed to variables used for income predictor modelling using Weka. The analysis relates to household characteristics including family size, number of household non-relatives, number of households with members below 5 years old, number of households with members ages 5 to 17, number of employed household members, household head age, household head
sex (coded as 1= male, 0= female), two (2) dummy or indicator variables reflecting household type (reference group: single family), three (3) for household highest educational level (reference group: none to elementary undergraduate) and four (4) for household marital status (reference group: single) while five (5) for household head employment status. In multiple regression, the regression coefficients associated with the dummy variables are interpreted as expected difference in the mean of that particular outcome variable as compared to the reference group, while holding all other predictors as constant.

By default, Weka sets eliminateColinearAttributes and attributeSelectionMethod settings to true to remove highly correlated input attributes and perform feature selection to only select those relevant attributes as attributes that are unrelated to the output variable can negatively impact performance. In addition, while classification results from Weka may yield a model for every cluster, a more robust model that applies to all clusters is deemed more relevant to assess income as income is distributed as a whole and not per cluster. The results are summarized in Table 9.

It can be gleaned from Table 9 that with $\alpha = 0.05$, many of the predictor variables associated with income are statistically significant. Age, for example, has a significant effect on income. As household head ages, the income may also significantly increase, as observed in salary schemes. As for marital status, a married household head is more likely to earn more among all marital status groups and as compared to being single. The significance of having more family members may be related to having more employed family members as having non-earning members such as those with ages below five years or from five to 17 years old are deemed to affect income negatively. Also, having more non-relatives in a household resulted to a positive effect as compared to having a single or extended family type. More likely, these results are also attributed to having more members who are capable to earn. In addition, it can be inferred that educational levels of household heads and employment status are highly significant predictors of income. However, household sex, although significant at $\alpha = 0.05$, is not suggestive of income as it negatively influences it.

Table 9. *Multiple Regression Summary*

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Regression Coefficient</th>
<th>Alpha: 0.05</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>58022.24381</td>
<td>6.368302837</td>
</tr>
<tr>
<td>Household Head Sex</td>
<td>-34512.92271</td>
<td>-8.378510202</td>
</tr>
<tr>
<td>Household Head Age</td>
<td>272.749464</td>
<td>2.367074312</td>
</tr>
<tr>
<td>Household Marital Status Married</td>
<td>48787.04835</td>
<td>7.771704559</td>
</tr>
<tr>
<td>Household Marital Status Widowed</td>
<td>7904.230257</td>
<td>1.133249017</td>
</tr>
<tr>
<td>Household Marital Status Divorced/Separated</td>
<td>22631.11719</td>
<td>2.574605742</td>
</tr>
<tr>
<td>Household Marital Status Annulled</td>
<td>150779.6473</td>
<td>1.99460795</td>
</tr>
<tr>
<td>Household Head Elem Grad- HS Undergrad</td>
<td>-24267.3744</td>
<td>-7.203878224</td>
</tr>
<tr>
<td>Household Head HS Grad- College Undergrad</td>
<td>44470.09401</td>
<td>13.95115868</td>
</tr>
<tr>
<td>Household Head College Grad- Above</td>
<td>277989.4313</td>
<td>69.21605395</td>
</tr>
<tr>
<td>Government</td>
<td>44437.34885</td>
<td>7.447574477</td>
</tr>
<tr>
<td>Worked for Private or Household</td>
<td>-58952.56429</td>
<td>-13.53804698</td>
</tr>
<tr>
<td>Self-employed</td>
<td>-43168.14748</td>
<td>-11.07148861</td>
</tr>
<tr>
<td>Employer in own family business</td>
<td>83565.9888</td>
<td>14.2493136</td>
</tr>
<tr>
<td>Work without pay in own business</td>
<td>-49185.66466</td>
<td>-3.152398765</td>
</tr>
<tr>
<td>Extended Family</td>
<td>12546.37361</td>
<td>4.115176371</td>
</tr>
<tr>
<td>Has two or more non relatives</td>
<td>32598.04048</td>
<td>1.675045018</td>
</tr>
<tr>
<td>Total Number of Family members</td>
<td>41686.21382</td>
<td>36.18086808</td>
</tr>
<tr>
<td>Members with age less than 5 year old</td>
<td>-54365.46952</td>
<td>-23.4162182</td>
</tr>
<tr>
<td>Members with age 5 - 17 years old</td>
<td>-46241.55038</td>
<td>-31.98534721</td>
</tr>
<tr>
<td>Total number of family members employed</td>
<td>27886.84979</td>
<td>19.13206114</td>
</tr>
</tbody>
</table>

4.3 Prescriptive

From the results of predictive analysis on drivers of income in households, some prescriptive analyses can be derived. Interestingly, in terms of education levels, it is evident that having a college degree and
above will more likely increase one’s capacity to earn more income as compared to other reference groups. Similarly, this result is reechoed by studies from other neighboring countries as reported such as Singapore, India, Vietnam and Thailand (Calderone, Sadhu, Fiala, Sarr, & Mulaj, 2018; OECD, 2010; Tran, Tran, Tran, & Nguyen, 2018). As education brings significant influence on income levels, it relates to a lesser probability of belonging to a lower-class income. The model resonates this result and it calls for possible projects relating to it as strengthening our education system and making it more available for the people will positively result to a movement in the capacity for income generation thereby affecting income classification in the future.

In addition, employment status also portrays a significant effect as working in a government and being an employer in a family or own business significantly affect a household heads’ income generation as compared to other reference groups, more so with being unemployed. Working for the government has been one of the pressing and demanding levels of employment that may decrease a household’s probability to belong to a lower class income (Villejo et al., 2014). Consequently, a significant growth rate of budget for personal services in the government as well as the implementation of salary standardization law is encouraged. Similarly, in Singapore for example, job security has become an important consideration for job seekers where being a civil servant means having a job that is guaranteed to be rather stable (Smith, 2019).

This paper also explored the possibility of a particular household to improve their level of income cluster in relation to expenses thereby moving one step higher, especially the poor bracket to lower middle-income class. We identified the average family income of cluster 1, and 2 as decision variable and the projected income value, respectively for the cluster 1 to move to cluster 2 group. We also identified the top seven (7) variables where Filipino family spends most.

Applying formulas and constraints using MS Excel Solver (Winston, 2011) to possibly generate an effect on the current income value of cluster 1, the solver reported an infeasible result. This means that regardless of lowering the value of the identified constraints on expenditures, it still does not significantly affect the value of the income to go higher (Ismail & Tendot Abu Bakar, 2012). However, solver suggested that for the Cluster 1 to advance in next income ladder, the average income should be increased to a greater value or the other sources of income should also be greater than the current income average. As revealed from literatures, most Filipinos at the lower income bracket spend most of their hard-earned money on food and necessities (Burger Chakraborty, Sahakian, Rani, Shenoy, & Erkman, 2016), and regardless of how small the income they received, the spending behavior have always been higher than current income they have (Ulep & Dela Cruz, 2015). Filipinos also have a behavior to spend on things that are not their immediate need (Schanzenbach, Nunn, Bauer, & Mumford, 2016; Te et al., 2017), and to spend spontaneously thinking that money could be earned in some other way (Pew Research Center, 2016). Consequently, this projects a compelling need for financial management skills that would somehow guide Filipino household on spending smartly (Hunter & Adal, 2017).

In comparison with Singapore, they reported that they exhibit real growth in terms of average household income from work per household member based on cumulative data from 2013 to 2018 (Singapore, 2018). Along this line, their expenditure data also shows an increasing trend as it grows relative to the spurt of income (Singapore, 2019). While income grows, households also tend to alter their spending patterns rapidly (Jappelli & Pistaferri, 2010). Apparently, household spending is considered a core driving force of economic growth as it represents more than half of GDP in most developed economies (Chai, Rohde, & Silber, 2015). In this case, increasing the capacity to generate income should be improved as it gives a long—term benefit as compared to just cutting down expenses. The ability to build wealth is not all about cutting expenses to save money (Loudenback, 2019). Accordingly, cutting on expenses will hurt the economy in the short run due to the decrease in demand and in return, government money to be propelled into the economy will also be less (Romer, 2011). As a result, a focus on increasing income thereby increasing demand should also be considered. As such, this paper is encouraging the government to develop policies that may open opportunities for households to generate income through entrepreneurial, employment and educational opportunities.
5. Conclusions & Recommendations

The study was able to present variables that may be considered in the policy development and strengthening of existing government programs by revisiting policies and ensuring its strict compliance, as an intervention to raising the quality of life of Filipinos. Two significant factors based on the predictive model of income emerged: education and employment. As education may increase the likelihood of full-time employment, thereby giving people access to high incomes, low level of education deprives people’s capacity to overcome economic challenges (Ross & Mirowsky, 2003). In effect, education should remain a priority of the government by holistically targeting students’ and teachers’ welfare that shall anchor developments in the system of schools in the country. Moreover, as instinctual as it can be, employment may drive households’ quality of life as having a good and decent job capacitate members ability to provide for the household. While government policies are in place for entrepreneurs, it is also worth venturing into new and radical ways for capitalization in order to open an alternative source of financing to combat existing challenges faced by micro, small and medium enterprises (Aldaba, 2012). Moreover, programs that will anchor sufficient available jobs should also be pursued continuously to decrease the rate of unemployment in the country. As households tend to diversify when they become more affluent, policies or programs that shall boost households’ capacity to generate more income from different sources is also encouraged.

However, this study is not without limitations. While it provided evidence on variables that may significantly affect the living conditions of Philippine households, this study remains to be exploratory in nature by applying data mining techniques in determining a predictive model for income using household head and individual characteristics and descriptively presenting expenditure patterns of families. It is also the interest of this study that other household variables based on the data be checked as other combination of factors from the FIES data set may yield a better model with higher predictive power towards income. Also, the prediction of income and expenses did not consider any underlying economic factors such change in prices and inflation rates. As such, the prediction may have a significant difference from the actual result. Moreover, the use of historical data of FIES before 2015, if and whenever available, may also be done for comparison and for richer data analysis. Nevertheless, results relating to determinants of income need to be given attention while other factors can be added for further studies to create a more robust model in the future.

References


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Learning Style Prediction Using Students’ E-textbook Reading Behaviors Data

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Abstract: Adaptivity is one of the most prominent features of intelligent textbooks in the 21st century. Learning style is a personality characteristic of learners, which is used to describe learners' preference for processing information in a certain way. Learning style was often measured by questionnaires, which were easily influenced by learners' subjective cognition and external interference. This study proposes a data-driven approach to automatically detect learning style of learners. In the learning environment of e-textbook, 234 students' reading data was collected, and a learner model is constructed using machine learning technology. The results show that the proposed model achieves a promising performance in prediction learning style. This will help measure learning style more accurately and provide support for personalization. The learner model applied to e-textbook can promptly and dynamically monitor the changes of students' learning behavior in the online environment, and adaptively intervene, remedy or enhance.

Keywords: intelligent textbook, adaptivity, machine learning, learning style

1. Introduction

E-textbooks are believed to play an important role in future learning, but most of existing e-textbooks have not considered readers’ personalities. Recently, there are increasing interests from educational technology community in designing intelligent e-textbook. Intelligent e-textbook is essentially an adaptive learning system that can provide learners personalized learning service. Usually, an adaptive learning system includes four parts: content model, learner model, instructional model and adaptive engine (Ritter et al., 2020).

Learning style (LS) is the personality characteristic of learners, which can be a part of leaner model. Learners with different LS have different learning preferences. That is to say, in the face of a certain theme or contents presented by e-textbook, students tend to select individual reading resources and adopt specific reading strategies (Gomede, Barros, & Mendes, 2020). Some studies have found that LS can guide the e-textbook to improve students' learning process (Truong, 2016). Therefore, the design of e-textbooks should consider the differences of learners' LS and optimize the learning process.

Many researchers classify LS according to different standards, hoping to recommend suitable reading resources and find effective reading strategies for learners. Compared with other LS models, Felder-Silverman learning styles model (FSLSM) has a more detailed classification of LS. FSLSM summarizes learners’ learning preferences from four dimensions of information processing, perceiving, inputting and understanding (Felder, & Silverman, 1988). The first dimension of FSLSM is divided learners into active and reflective according to whether he prefers cooperative inquiry or independent reasoning. The second dimension is divided into sensing and intuitive learners according to whether he prefers touching things to learn or observing things to learn. The third dimension is divided into visual and verbal learners according to whether he prefers to see charts, tables, and figures or words and texts. The fourth dimension can be divided into sequential and global learners according to whether he prefers to acquire information step by step or overall grasp.

As we all know, the traditional method of LS measurement is based on questionnaires or scales. It has two major problems. On the one hand, it takes a lot of time to fill in the questionnaires and process...
data (Aissaoui, Madani, Oughdir, & Alliou, 2019). On the other hand, this method is easy to be interfered by external factors, for example, students' comprehensive deviation will affect results of the measurement (Bernard, Chang, Popescu, & Graf, 2017). To solve these issues, this study proposes a data-driven approach for measuring students' LS. The aim of this study is to propose a easy-to-use method that detect e-textbook readers' LS automatically and accurately.

2. Related Work

2.1 Adaptive Intelligent Textbook

Intelligent textbooks are considered as family members of adaptive systems. The adaptive system usually includes four parts: content model, learner model, instructional model and adaptive engine. Among them, the content model covers various knowledge components and prerequisite relationships. The learner model includes personalized features of learners and interactive behaviors with e-textbook. The instructional model recommends appropriate teaching resources and skills. The adaptive engine is responsible for recommending the learning strategies and adjusting learning materials according to the adaptive rules. At present, the research on these four parts is not completely mature (Boulanger & Kumar, 2019).

(Huang, Yudelson, Han, He, & Brusilovsky, 2016) summarizes the latest development of intelligent textbooks in the past. Previous studies mainly focused on content model and learner model. The first generation of adaptive textbooks focuses on tracking learners' knowledge status and uses adaptive navigation technology to recommend students to read the most relevant pages (Thaker, Brusilovsky, & He, 2019). (Bommanapally, Subramaniam, Parakh, Chundi, & Puppala, 2020) constructs a knowledge repository of course learning objects in order to automatically generate personalized e-textbook. Among them, the knowledge content model is relatively complex, and the learner model rarely considers the students' personalities, which is relatively simple.

In the future, more personalities of learners should be considered into intelligent textbooks. And intelligent textbooks should not be regarded as a repository for learning and teaching activities (Ritter et al., 2020) or a tool of collecting data (He, 2014; Yin, Ren, Polyzou, & Wang, 2019), but as an adaptive system which make decisions by adaptive technologies.

2.2 Automatic Detection of LS Based on Data Driven Approach

Learners' learning style is not unchangeable. Spending a lot of time on the questionnaire will reduce learners' learning motivation (Dorça, Araújo, Carvalho, Resende, & Cattelan, 2016) Compared with the conventional ones, the data-driven approach has the following advantages. Firstly, it is more objective. Data-driven methods are based on data mining and machine learning technology (Aissaoui, Madani, Oughdir, & Alliou, 2019). The result is not affected by learners' subjective comprehension. Secondly, data-driven methods are dynamic. The e-textbooks will provide timely feedback on changes in students' reading behaviors. Thirdly, data-driven methods are more accurate. That is because the prediction results of LS are based on a large amount of students' reading behavior data.

According to the relevant literature, it can be found that researchers have been always looking for a data-driven mechanism for automatic detection of LS. For example, (Truong, 2016) classified data-driven detection of LS into three sub problems: consideration of learners' personal traits, selection of LS models and classification algorithm selection of learner model. Sub question 1 is the first step of learner model. (Normadhi et al., 2019) divides learners' personal characteristics into four categories: the mixture of cognition, affection, behavior or psychomotor and mix. For sub problem 2, previous studies have proved that FSLSM is the most suitable for adaptive e-textbook to detect LS compared with other LS models (Pham & Adina, 2013; Bernard, Chang, Popescu, & Graf, 2017). For sub problem 3, many researchers use different classifiers to implement the automatic prediction of LS (Bernard, Chang, Popescu, & Graf, 2017; Garcia, Amandi, Schiaffino, & Campo, 2007; Sheeba & Krishnan, 2019). Because the data-driven approach needs sufficient training data to achieve accurate identification of
personal traits, in this study, a mixture method of questionnaire and data-driven approach is used to detect learners' learning styles.

3. Data

With the help of e-textbook system, a system established by (Yin, Ren, Polyzou, & Wang, 2019), data was collected from a total of 234 students were collected. Each record contains students' ID, gender, scores of LS and reading behaviors data. There are 16 behavioral characteristic variables generated by students, as shown in Table 1. We add a feature variable SumMarkerC, which is used to represent the total number of students taking notes.

Table 1. Seventeen Behavioral Characteristic Variables

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCC</td>
<td>times of login using PC terminal</td>
</tr>
<tr>
<td>TabletC</td>
<td>times of login using tablet terminal</td>
</tr>
<tr>
<td>MobileC</td>
<td>times of login using mobile terminal</td>
</tr>
<tr>
<td>HighLightC</td>
<td>times of marking highlight</td>
</tr>
<tr>
<td>UnderLineC</td>
<td>times of marking underline</td>
</tr>
<tr>
<td>BookMarkC</td>
<td>times of marking bookmark</td>
</tr>
<tr>
<td>MemoC</td>
<td>times of marking memo</td>
</tr>
<tr>
<td>MarkerC</td>
<td>HighlightC + UnderLineC</td>
</tr>
<tr>
<td>SumMarkerC</td>
<td>total times of HighlightC, UnderLineC, BookMarkC</td>
</tr>
</tbody>
</table>

The scores of LS are measured by FSLSM, which is used for model training and performance evaluation. FSLSM consists of 44 questions, which are divided into four dimensions to describe learners' preference of processing, perceiving, inputting and understanding information. Each dimension has 11 questions. And each question has two options, "a" and "b". The number of "a" minus the number of "b" equals the score of each dimension. It is worth noting that the score can be only restricted to odd numbers between -11 and 11. Therefore, 12 types of LS are finally formed, as shown in Table 2.

Table 2. Classification of 12 types of LS

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Variable Name</th>
<th>Description</th>
<th>Learners' LS</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>activescore</td>
<td>activescore ∈ [3,5,7,9,11]</td>
<td>reflective</td>
</tr>
<tr>
<td></td>
<td></td>
<td>activescore ∈ [-1,1]</td>
<td>balance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>activescore ∈ [-11,-9,-7,-5,-3]</td>
<td>active</td>
</tr>
<tr>
<td>D2</td>
<td>sensingscore</td>
<td>sensingscore ∈ [3,5,7,9,11]</td>
<td>intuitive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sensingscore ∈ [-1,1]</td>
<td>balance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sensingscore ∈ [-11,-9,-7,-5,-3]</td>
<td>sensing</td>
</tr>
<tr>
<td>D3</td>
<td>visualscore</td>
<td>visualscore ∈ [3,5,7,9,11]</td>
<td>verbal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>visualscore ∈ [-1,1]</td>
<td>balance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>visualscore ∈ [-11,-9,-7,-5,-3]</td>
<td>visual</td>
</tr>
<tr>
<td>D4</td>
<td>sequentialscore</td>
<td>sequentialscore ∈ [3,5,7,9,11]</td>
<td>global</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sequentialscore ∈ [-1,1]</td>
<td>balance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sequentialscore ∈ [-11,-9,-7,-5,-3]</td>
<td>sequential</td>
</tr>
</tbody>
</table>

The personalized characteristics of the balance are relatively not obvious while the other two types are obvious and the differences are relatively large. Therefore, this study first eliminates learners'
data of the balance, and transforms the multi classification prediction problem into a binary classification problem.

4. Methods

Learning style prediction process is divided into five steps, including data exploration, determination of prediction target, dimension reduction, construction of learner model and evaluation of model performance, as shown in Figure 1.

![Flow chart of LS prediction process](image)

The data exploration mainly focuses on the distribution of LS and the differences of reading behaviors among LS. The distribution will affect the choice of the selection of evaluation methods and evaluation indicators. If there exists the problem of data imbalance among categories, the three methods can be used before next step: over-sampling, under-sampling or mixed-sampling.

Feature selection and feature extraction are usually used to achieve dimensionality reduction. Feature selection is to directly select a few dimension data from high-dimensional data to represent the whole; feature extraction reduces the dimension of feature matrix by establishing mapping relationship between high-dimensional data and low-dimensional data. In this study, PCA (Jolliffe, 1986) and Lasso (Tibshirani, 1996) were used. PCA is a feature extraction method and Lasso is a feature selection method.
The construction of the learner model is mainly divided into the following parts: determining the LS model, selecting the classifier, dividing the proportion of training set and test set, and determining the super parameters. In this study, we would like to attempt to use four types of classifiers, including LR (Cox, 1958), NB (John & Langley, 1995), DT (Quinlan, 1992) and SVM (Cortes & Vapnik, 1995).

In addition, it is necessary to consider the evaluation methods and indicators of model performance. In order to reduce over fitting in a certain extent and obtain as much effective information as possible from limited data, 10 fold cross validation (Golub, Heath, & Wahba, 1979) is introduced. Considering the imbalance of data, it is not rigorous to evaluate the performance of the model only with the accuracy and F1 measurement is selected.

5. Results

5.1 Data Exploration and Analysis

The distribution of 234 students’ LS is shown in Figure 2. The conclusion can be drawn that the distribution of D1 and D4 is relatively balanced, while that of dimensions D2 and D3 is very unbalanced. Therefore, we use the mixed sampling method to preprocess the data for D2 and D3.

![Figure 2. Distribution of 12 Types of LS in Four Dimensions](image)

This study aims at e-textbook identifying students’ LS automatically and more accurately in terms of students’ reading behaviors data. At first, we should learn about whether there are significant differences among groups with different LS and what the differences are. One-way ANOVA is adopted. Before that, independence, normality and homogeneity of variance within the group passed the test.

<table>
<thead>
<tr>
<th>Table 3. Variables with significant difference in D3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading behaviors</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
</tbody>
</table>

336
The results show that the first dimension has significant difference in MobileC \((p=0.045)\), marginal significant difference in HighlightC \((p=0.065)\), MarkerC \((p=0.077)\) and SumMarkerC \((p=0.095)\). The second dimension has marginal significant difference in ReadPages \((p=0.065)\) and NextC \((p=0.066)\). The fourth dimension has marginal significant difference in GPA \((p=0.066)\).

The third dimension has significant difference in BookMarkC \((p=0.048)\), HighlightC \((p=0.065)\), MarkerC \((p=0.027)\) and SumMarkerC \((p=0.021)\), marginal significant difference in MemoC \((p=0.055)\), Middle \((p=0.074)\) and GPA \((p=0.057)\), as shown in the Table 4.

<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>SD</th>
<th>MD</th>
<th>M</th>
<th>SD</th>
<th>MD</th>
<th>M</th>
<th>SD</th>
<th>MD</th>
</tr>
</thead>
<tbody>
<tr>
<td>BookMarkC</td>
<td>1.93</td>
<td>4.54</td>
<td>1.00</td>
<td>2.71</td>
<td>4.83</td>
<td>1.00</td>
<td>3.72</td>
<td>9.41</td>
<td>0.00</td>
</tr>
<tr>
<td>HighlightC</td>
<td>14.1</td>
<td>17.9</td>
<td>6.00</td>
<td>22.1</td>
<td>27.2</td>
<td>15.0</td>
<td>25.3</td>
<td>26.5</td>
<td>26.0</td>
</tr>
<tr>
<td>MarkerC</td>
<td>15.4</td>
<td>19.1</td>
<td>7.00</td>
<td>26.2</td>
<td>33.5</td>
<td>16.0</td>
<td>26.2</td>
<td>27.0</td>
<td>29.0</td>
</tr>
<tr>
<td>SumMarkerC</td>
<td>27.9</td>
<td>32.5</td>
<td>15.0</td>
<td>43.2</td>
<td>48.1</td>
<td>29.0</td>
<td>51.0</td>
<td>50.3</td>
<td>58.0</td>
</tr>
</tbody>
</table>

It can be obviously concluded in Figure 3, verbal learners make notes the most of BookMarkerC, HighlightC, MarkerC and SumMarkerC, while visual learners do the least. Comparing the median and the average of the four reading behaviors, we can find that more than 50% of the verbal learners are above average. More than 50% of the visual learners are below average and the balanced learners are in the middle. In other words, most verbal learners have the habit of taking notes, while most visual learners do not.

5.2 Evaluation of Learner Model

We select the popular F1 measure as the evaluation indicator of model performance. According to calculation formulas of F1, Table 4 lists results of the performance evaluation. For D2 and D3, DT classifier have the best prediction performance compared with other classifiers. The maximum F1 measurement of D2 can reach 83.33% and that of D3 can reach 95.63%. For D1 and D4, the four classifiers have poor prediction performance, and F1 measurement ranges from 49.59% to 66.00%. Generally, there is no significant difference between the two methods of dimension reduction.
### Table 4. Results of the Model Performance

<table>
<thead>
<tr>
<th></th>
<th>F1</th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PCA</td>
<td>LASSO</td>
<td>PCA</td>
<td>LASSO</td>
<td>PCA</td>
</tr>
<tr>
<td>LR</td>
<td>63.49%</td>
<td>66.00%</td>
<td>71.43%</td>
<td>75.06%</td>
<td>70.00%</td>
</tr>
<tr>
<td>NB</td>
<td>60.23%</td>
<td>55.35%</td>
<td>72.86%</td>
<td>70.48%</td>
<td>78.33%</td>
</tr>
<tr>
<td>DT</td>
<td>58.37%</td>
<td>62.00%</td>
<td>81.43%</td>
<td>79.40%</td>
<td>83.33%</td>
</tr>
<tr>
<td>SVM</td>
<td>61.33%</td>
<td>61.40%</td>
<td>78.57%</td>
<td>71.96%</td>
<td>81.67%</td>
</tr>
</tbody>
</table>

### 6. Discussion

In this study, the data collected from e-textbook is first mixed-sampled to solve the problem of imbalance. Then a learner model for predicting LS is successfully established. The model is evaluated by confusion matrix method. The results show that the model performs well in the two dimensions of the FSLSM. It can be observed from the results obtained that the learner model may be used to identify students’ LS based on their reading behaviors data in e-Textbook. The data-driven approach is used to automatically identify students’ LS in this study. This method avoids the external interference and subjective understanding bias caused by the traditional LS measurement method based on the questionnaire. It has the advantages of dynamic adaptiveness, objective feedback and higher accuracy.

Thus, by identifying students’ LS, the model can not only guide the development of intelligent textbooks, but also recommend learning materials suitable for learners with different LS in order to improve the learning process. For example, more than half of verbal learners have the habit of taking notes while visual learners do not in this sample. For verbal learners, intelligent textbooks can first recommend more text-based learning resources or additional supplementary materials; for visual learners, visual learning resources such as pictures are presented first. In addition, it has a positive impact on learners. Learners can perceive their own learning preferences and obtain personalized learning materials, which can reduce their cognitive load and improve their self-confidence (Durak & Saritepeci, 2018).

As a family member of adaptive systems, intelligent textbooks provide personalized feedback and support through learners' autonomous learning. Instructional model, learner model, domain model and adaptive engine are four parts of the adaptive system, which have become valuable researches and are worth breaking through all the time. Learners' personal traits belong to the content of learner model, and most studies use LS to simulate learners' personalities. It is important to take advantage of LS automatic detection to design adaptive system so as to provide better personalized service (Boulanger & Kumar, 2019). In the future work, we will classify the learning resources and mark the key pages based on the results of this study (Deligiannis, Panagiotopoulos, Patsilinakos, Raftopoulou, & Symvonis, 2019). This will help provide learners with selective references of peers, who has the same LS, so as to read the key content back correctly and effectively for the purpose of providing support for personalization (Pursel, Ramsay, Dave, Liang, & Giles, 2019; Ritter et al., 2020).

### Acknowledgment

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A Meta-review Analysis of Research on Technology-assisted Content and Language Integrated Learning

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Abstract: Currently, the integration of Content and Language Integrated Learning (CLIL) and digital technology has become widespread all around the world mostly in European countries, which is used for teaching English as a foreign language. However, the trend of using digital technology integrated CLIL in English language education still lacks systematic analysis. The present study aims to examine the published research articles in academic journals, indexed by the Scopus database from 2010 to 2019 was conducted to investigate in terms of nationalities, authors, journals, research methods, research issues, technology learning materials, and educational stages. The finding revealed that the use of CLIL integrated digital technology in English language learning has been positively successful in developing students’ learning motivation and competence, not only technological skills but also content subjects and English language competencies. The results show that video technology was the most popular tool for enhancing students’ motivation and promoting students’ learning ability in English language within the context of CLIL methodology. Therefore, the highest interesting research method was system development that concern of digital technology development which contributes to better effective learning tools. Based on the overall finding, it is clear that CLIL integrated digital technology is an effective tool in English foreign language learning. Although the studies quite still rather low in the last recent year and also mainly in European countries that focusing on higher educational participants, it could bring some challenges of the limited practice to explore the use of CLIL blended technology in learning English in school within Asian countries that are increasingly bilingual setting.

Keywords: CLIL, Digital technology, Language learning, English language education

1. Introduction

Nowadays, more than ever before, the world has entered the 21\textsuperscript{st} century that is an era of progress in politics, economy, society, especially technology and innovation. The world has turned into an enormous and interconnected network. English has become a universal language that is being taught all over the world. The importance of being well in English comprehension is heavily emphasized, ensuring that future generations can survive in a globalized world. On the contrary, the increasing demand for English language has made it an invaluable skill but the traditional learning English in the classroom is not enough anymore. Language teaching is not limited to direct language teaching like before. The integration of content subjects should be used in teaching and learning language. Content and language integrated learning (CLIL) is a phenomenon that is occurring all over the world, many countries already successfully use CLIL in practice. CLIL is based on the integration of subject and language content together refer to teaching of non-linguistic subjects (e.g. Science, Mathematics, History) through the medium of a second or foreign language. CLIL is learning to improve and develop students to have a learning experience from the integration between the two subjects (Pitura & Chmielarz, 2017). CLIL is a dual-focused approach which is a method that gives equal attention to language and content that is widely accepted as teaching (Mehisto, Marsh, & Frigols, 2008). Besides, CLIL can be used for improving the efficiency of language learning and for motivating learners. Several research outcomes
have been resulted in learning performance improving and motivation encouraging. CLIL learners were better target language performance, high motivation, and more linguistic and academic ability (Bruton, 2011).

People in the 21st century usually live in a modern technology environment such as computers, tablets, smartphones, and digital media. It can be said that children who are growing up in this 21st century are digital natives, they have a different lifestyle from the past. The impact of technology can be touch in every possible field, including in education. Currently, the way of students learning in the classroom is changed, because today’s students’ backgrounds are quite dissimilar from the former times (Taranto, Dalbon, & Gaetano, 2011). Technology has been also increasing in English language learning and teaching to make the learning environment more effective, enjoyable, and comfortable. Several studies have been conducted to determine the use of technology in various platforms to enhance students in English language learning, computer-assisted instruction could also assist in vocabulary advancement as well as verbal language advancement with the exact positive outcome (Timothy, 2005). Beyond, the use of mobile phones and/or smartphones and their applications create positive effects on learning English as a foreign language in the development of learners’ vocabulary and their increased students’ learning motivation (Klimova, 2017).

Since the popularization of CLIL and technology, the integration of content and language integrated learning (CLIL) and technology has become an increasingly important role in supporting the development of students’ foreign language skills and increasing understanding of subject matter. Numerous researchers in a wide range of fields have discussed their benefits. There is growing evidence that in the right context, CLIL and technology can be used to enhance students’ motivation and learning outcomes. All in all, CLIL and technology combination resembles to be a trending area of research and practice. This systematic review expands the existing literature by framing the discussion around.

2. Literature Review

2.1 Content and Language Integrated Learning (CLIL)

The term “content and language integrated learning” (CLIL) was introduced by the European scholar David Marsh in 1994 (Coyle, Hood, & Marsh, 2010) as an attempt to combine language and content through a foreign language (mostly English language). CLIL has been received wide recognition due to being universal and simply adaptable to all foreign languages (Maljers, Marsh, & Wolff, 2007; Marsh, 1994). CLIL is an effective approach to enhancing English competence as it helps students improve a positive attitude towards themselves as language learners (Mehisto & Marsh, 2011). Likewise, technological advances and innovation are now an essential part of the educational course all around the world. Technology presents an excellent opportunity for communicative language learning. Digital technology can be adapted to the new educational trend that is content and language integrated learning (CLIL) and help learners develop their language learning as it simplifies dynamic education, the ability to share experiences in the foreign language (Marsh, 2001).

In recent years, several studies about the integration of content and language integrated learning (CLIL) and technology in foreign language learning have been presented. The simple technology integration of CLIL can be observed using PowerPoint presentations and viewing YouTube videos (Esteban, 2015). CLIL and technology integration is widely found among using a variety of technology resources. For instance, the use of video to motivate students’ motivation in learning history and science subjects within the CLIL. The finding indicated that students’ are more motivated when learning history and science subjects through CLIL approach if videos are used, the use of videos in the classroom motivates students by creating a relaxing and comfortable environment in CLIL educational setting (Tragant, Marsol, & Serrano, 2015). Additionally, applying gamification to an extracurricular CLIL project intended to develop students’ perceptions in biology. The result showed that students were driven by enjoyment, curiosity, as well as a sense of community and achievement with the new digital tools. Students connected English language skills by using language challenging social activities, where was the basis on content and not on language (García & Jurado, 2019). Moreover, the result of an
integration of CLIL and Web 2.0-based teaching materials indicated that the positive changes in the state of the experiment group.

According to the literature review, the popularization of researchers who are attempting to apply the integration of CLIL and technology to develop students’ competence, providing educators with information to prepare appropriate learning activities for their students, and what designers need to consider when creating English language learning within CLIL integrated technology. To enable the research and development in teaching English as a foreign language toward CLIL and technology combination to become more enlightened, analyzing previous research trends in the integration of CLIL and technology in foreign language education has become significant. To provide more details, the literature was analyzed to understand the finding of CLIL and technology combination in foreign language education in the past, the research trends and issues are suggested.

3. Research Methodology

3.1 Resource

This research study investigated papers from the Scopus database from 2010 to 2019 by searching for the publications whose titles, abstracts, or keywords met the logical condition (“CLIL” or “content and language integrated learning” and (“technology” or “technologies” or “technological”). A total of 81 papers published in journals were appropriated for this study. By removing 46 non-article papers and non-English papers, 35 papers were included in the present study by deleting 25 papers which were not related to the integration of CLIL and technology in English as a foreign language learning. Therefore the total papers that mention in the integration of CLIL and technology in English as a foreign language learning are 10 papers. The following diagram in Figure 1 shows the steps of searching for papers on the Scopus database.

![Figure 1. Scopus database searching steps](image)

3.2 Data distribution
There were 81 papers in this review. The papers were classified and reviewed by two researchers based on the coding schemes. If there were contradictory coding results, they would discuss until an agreement was reached.

Figure 2 illustrates the papers on the integration of CLIL and technology in English as a foreign language learning from 2010 to 2019. There were no literature reviews on CLIL and technology combination in English as a foreign language learning in 2010; after 2010, no more than 5 papers on the integration of CLIL and technology in the foreign language were published each year. The scholars took more interested in this field since 2016, with 4 papers published in 2016.

Figure 2. Published papers on the integration of CLIL and technology in English language learning from 2010 to 2019

3.3 Coding schemes

In the present review, the categories for analyzing the contents in this study, composed of nationalities, authors, journals, research methods, research issues, (Chang & Hwang, 2019; Chang, Lai, & Hwang, 2017) technology learning materials, and educational stages. The following items describe the coding scheme in each dimension:

Nationalities, authors, and journals: The standard information of those published papers are discussed, including authors, nationalities, and journals. The objective is to realize that who and which countries have more frequently published papers on the integration of CLIL and technology in English language learning.

Research methods: The category of research methods was based on the 4 common research methods consisting of the system development, questionnaire survey, qualitative research method, and mixed methods.

Research issues: The research issues examined CLIL blended technology in English education including the affective aspect and cognitive aspect.

Technology learning materials: Technology integrated CLIL setting were Web Quests, video, web 2.0, digital content such as social media (that is blogs), YouTube, Facebook page, multimedia, audio, online web (online dictionary, TESOL websites, Google search, and telecollaboration), and digital game.

Educational stages: The education stages of participants in CLIL and technology combination in English language learning were primary education, upper secondary education, higher education, and teacher.

4. Research results

4.1 Nationalities, authors, and journals

In this review, the researchers examined only the nationalities of the first author of the papers on CLIL and technology combination in English as a foreign language learning. The result pointed out the most
The journals which published are Social Sciences (Pakistan), Education for Chemical Engineers, Mondo Digitale, Journal of Language and Literature, Anthropologist, International Journal of Educational Technology in Higher Education, Teaching English with Technology, Cypriot Journal of Educational Sciences, Theory into Practice, and Multidisciplinary Journal of Educational Research. The statistical results of the authors and journal titles in Figure 4 could be a good reference to those who intend to publish the integration of CLIL and technology in English learning or host relevant workshops or conferences in the future.

4.2 Research methods

In this study, the researchers evaluated the research methods in each article including the system development, questionnaire survey, qualitative research method, and mixed methods. Six papers were adopted in the system development which developing digital technology and online website then verified its effects. The other two papers were divided into documentary research that is a qualitative research method, which examined an example of the use of technology combined CLIL in English language learning and another paper adopted in the mixed method which indicated the use of video within the classroom motivated students. Another paper was classified into a questionnaire survey that
explored students’ learning development in English through CLIL integrated technology.

Figure 5. Research methods on the integration of CLIL and technology in English language learning from 2010 to 2019

4.3 Research issues

The research issues were analyzed in CLIL integrated technology in English language learning including cognitive aspect and affective aspect. The results show that the studies on the cognitive aspect for 6 papers and the other 5 papers focused on both cognitive and affective aspects. Thus cognitive domain and affective domain were mainly concern with most CLIL blended technology in foreign language education research. Numerous researchers intended to integrated technology into the CLIL classroom by creating a modern technological environment in a bilingual setting to develop students’ competencies in both language and technology knowledge. Furthermore, some researchers focus on both motivation and knowledge at the same time because motivation is determined to be one of the considering factors that effective learning in any context.

Figure 6. Research issues on CLIL and technology combination in English language learning from 2010 to 2019

4.4 Technology learning materials

Technological advances are now an indispensable part of language education. In this study, we examined the integration of digital technology into CLIL class. Figure 7 displays a summary result on the application of several technology teaching materials in a foreign language. The top three highest number of technologies for CLIL-based English language learning are video, online web, and web quest with five, four, and three total papers, respectively. Likewise, the analysis shows other technologies are web 2.0 and audio.
4.5 Educational stages

The researchers investigated the educational stages of the participants in this research including primary education, upper secondary education, higher education, and even teacher. Figure 8 illustrates the participants involved in learning English as a foreign language through CLIL integrated technology. The result shows that almost the participants were higher education which took place in the university with 6 papers. Even most of the papers investigated the integration of CLIL and technology in English language learning were effective in higher education, applying the combination of CLIL and technology in English language learning into the school could be challenging. To the point of view, the integration of technology and CLIL in English as a foreign language learning did not only focus on students but also the teachers because of the teacher teaching perspectives needed to give priority.

Figure 8. Ratio of educational stage on the integration of CLIL and technology in English language learning from 2010 to 2019

5. Conclusion and discussion

This study was examined a meta-review and analysis of the integration of CLIL and technology in English as a foreign language learning from 2010 to 2019. The results revealed that even the polarization of the use of technology in English language education and the most successful of CLIL approach were impacted on students’ motivation and their competence but the number of the study of CLIL integrated technology in learning English was still quite low and mainly in European countries that the original of
CLIL approach and famous bilingual education area, due to the limited of the language instructors’ in content knowledge, language skills, or technological competencies. It is not easy for the instructor to be skilfully in all three main skills (content subjects, language skills, and technology competencies) and applying in the teaching process. It was found that a lot of studies used system development of technology in the CLIL environment which focuses on English language learning that means the researchers tried to engage the technology advantages in language learning.

Additionally, it was highlighted that the research issues both motivation and learning outcomes were most investigated in this area. This indicated that learning English in CLIL blended technology not only focuses on students’ enjoyment experience in developing technical competencies but also engaged subject contents and language skills at the same time which remains a challenging and important issue.

In contrast, it can be found that various technology platforms in CLIL integrated technology in English learning such as multimedia, digital game, and audio. The most popular technology tools were video and online website because of the technology advantages; an excellent interactive media that students could look at the picture, hear the sound and real-time interactive media, therefore students can learn English language in the real situation while they received the information from those technology tools. Besides, even most studies took part in the participants in higher education, it will beyond the challenge to apply technology combined CLIL in English language learning in school.

References


Curating an OER Course by Applying the Learner-Centric MOOC Model

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Abstract: Use of Open Educational Resources (OERs) is on the rise, and many new models can be seen emerging in the educational technology domain. One of the prominent techniques is to ‘curate’ OERs and augment them with customized / aligned activities instead of creating new resources. This paper presents the study of an OER course titled ‘Creation by Curation’ developed based on the LCM model. The course was developed using curated OERs and elements of the Learner-Centric MOOC model (LCM) were used to augment and contextualize the OERs. This paper enquires perception and acceptance of participants towards curated OERs instead of instructor-developed videos as well as the interactivity and engagement with curated OERs used as course content. Findings of this study report a favourable perception of participants towards curated and augmented OERs. The study suggests application of the LCM model to augment the OERs enhanced interactivity and engagement.

Keywords: OER, Curation of OERs, Augmentation of OERs, LCM model, Learner engagement

1. Introduction

The concept of Open Education Resources (OERs), since its inception in a UNESCO conference in 2002 has travelled the globe and has transformed into a larger domain called as Open Education (OE) comprising various types like OERs, Open Courseware (OCW), Open Courses, Open textbooks, Open Library being the prominent ones. OER movement has become synonymous with democratization of education with the usage of OERs strongly founded on principles of sharing and participation. Despite the buzz around Open Education and OERs and its benefits, its acceptance and integration into Education still poses a question. It is the educators, trainers and the researchers that play a pivotal role in establishment of the concept of OERs and its usage and implementation.

There is a sharp rise in creation of OERs with more and more academicians and publications releasing their content in ‘open’ format on various platforms (Bliss & Smith, 2017; Wiley, 2007). It is difficult to ascertain the exact number of OERs created and available which could possibly be a few thousands of OERs. The major hurdles documented in the adopting OERs by teaching fraternity are: lack of awareness, institutional policies and their own perceptions (many of them being negative) towards the quality and validity of the OERs. Research has pointed out that the lack of ICT skills in teachers, along with the lack of knowledge of adapting OERs adds to the gap between the OERs available and the OERs used and practiced (Orwenjo & Erastus, 2018).

Though OERs provide avenues for adaptation of the resources, their adoption needs teachers to understand the fundamentals and possibilities of adaptation of resources. Traditionally, teachers of all levels have been conditioned to using textbooks in the ‘use-as-is’ format. It was noted that teachers would need guidance for curation, adaptation, and adoption. A course entitled ‘Creation by Curation’ using curated OERs was developed to demonstrate the principles of curation to educators. The Learner Centric MOOC (LCM) model (Murthy, Warriem, Sahasrabudhe, & Iyer, 2018) was used to augment the OERs curated for the course. This carried the benefit of an additional research angle with regards to engagement of participants in an OER course. The case study in this paper suggests that the LCM model
enhanced the engagement of participants in the course. The case study reveals the influence of LCM model in contextualizing and adapting the OERs, thus making them favourable for curation concurrent with the principles (5Rs) of OER usage.

2. Literature Review

Importance of OER initiatives are highlighted in the policy decisions (UNESCO 2012, European Commission 2013, Cape town Open Education Declaration 2017). Several nations including India have established their OER repositories through government initiatives. (Wiley, 2007). Interestingly, 1700 courses from seven University based Projects in USA, 451 from 176 University members of China, 350 courses from 10 Universities in Japan and 178 courses by universities in France as OERs are reported (Falconer, Littlejohn, McGill & Beetham, 2016).

The potential benefits of using OERs reported are varied such as increase in the collective efficiency of educators (Hoosen, 2012), increasing the breadth of course offerings (Hoosen 2012, Falconer et al), minimizing barriers -economic and geographical- to higher education (Butcher & Hoosen 2012). Significant barriers to the usage of OERs have been reported. A few of them are academic competition and branding (Dholakia, King & Baraniuk, 2006; Falconer et al, 2016, Sexias, Dove, Ueberschar & Bostock, 2014), low awareness regarding availability and usage (Sexias et al, 2014). Additionally, concerns regarding quality and trust (Grodecka & Sliwowski, 2014; Clement & Pawlowski, 2012) and the ease of technology integration (Atkins et al, 2007; Clements & Pawlowski 2012; Sexias et al, 2014) were reported as major barriers for usage of OERs.

The buzz around the Open Education movement led to public and private initiatives all over the world. The Government of India formally recognised the usage of OER in education and the National Knowledge Commission (NKC) was subsequently established in 2008 followed by NROER in 2013. After that, there have been several initiatives in the field of OER in India.

Despite this, the challenges in usage of OER are aplenty. Other than a few researchers like Das (2011), Sharma, Mishra and Thakur (2014) and Venkaiah (n.d) have reported insights into the usage trends with the specific case of India. Lack of teacher training with respect to awareness, skill in using OERs in education and lesser availability of OER in regional languages were some major barriers recognised in the case of India (Padhi, 2018). Other than these few researches, there is sparse literature on OER usage in India. This indicates the need for deeper research into the OERs.

This paper is based on the case study of the online course- ‘Creation by Curation’ and outlines how the curated and augmented OERs were leveraged as major course content. This study further explores the acceptance of the curated OERs as course content by the participants and their engagement in the course.

3. The study

This case study is based on the 4 week open online course ‘Creation by Curation’ conducted on the Gnomio platform. The development of the course was based on two major constructs: Curation of OERs, adapted suitably and the LCM model as structure of the course (See Figure 1). For example, the videos chosen as course content were augmented into Learning Dialogues (LeD) as per the LCM model using tools (such as H5P). H5P was used to introduce the ‘Reflection Spots’, reducing the passivity and allowing the learners to reflect on the content.
3.1 Context:

The ‘Jožef Stefan’ Institute in Ljubljana (Slovenia) launched an online mentoring program entitled ‘Open Education for a Better World’. The program is aimed to unlock the potential of open education for achieving the Sustainable Development Goals by the UN. The course ‘Creation by Curation’ was offered as a part of the ‘Open Education for a Better World’ online mentoring program with a goal to enable educators to curate their own online course.

The participants were faculty members or research scholars from various disciplines from institutes of Higher education across India. The participants were from domains like Science, Engineering, Humanities, and Management. The participants had a varied level of experience ranging from 2 years to 15 years or more. The average experience of the participants was estimated to be 10 years. Some participants also held senior administrative positions in their institutions.

3.2. Method: Case study

Research in OERs is a relatively new area of research and so is curation of content to a majority of faculty. Choosing this course ‘Creation by Curation’ as a case study was considered as appropriate since the content of the course was largely curated content. This allowed the study of a few prime areas of OER research.

The case study begins with the documentation of development of this course using curated OERs and their augmentation as per the LCM model used for enhanced learner participation and engagement. The focus of this case study was to gain insights on participants’ perception on the usage of curated OERs and their engagement with the same.

A survey was conducted to collect the perceptions of the participants who had successfully completed the course, regarding the course content, activities, duration as few parameters. This was followed by a telephonic interview of the participants who had completed the survey and had given their consent for the interview. The semi-structured interview probed on aspects such as the type of content they found more engaging, their perspectives on the curated course, process of curation and its application.
3.3. Research Questions:
This case study addresses multiple questions that arise in conducting an LCM Model based course using curated OERs. These questions ranging from the perception towards the curated OERs to the engagement in such a course are studied with the following specific questions.
1. What was the perception/ acceptance of the curated OERs augmented using the LCM model?
2. How was the LCM model used to augment the OERs to make them adaptable as curated content?
3. How did the augmented OERs engage the participants in the curated course?

3.4. Data Collection

The participants were tracked for the entire duration of the course. The analytics of the Gnomio platform were used for the purpose. The analytics could track the activity of each participant on each of the elements of the course including the activity completion. This helped to identify consistently active participants who could complete the course as well as those who were consistently active except the last week which did not allow them to be certified. The course saw active participation of 43 (31 male and 12 female participants) out of which 29 completed all aspects leading to their certification. This further enabled purposive sampling for this study.

The next step for data collection from the sample was the feedback to the course and the consent to telephonic interview. The feedback form of 10 questions collected responses regarding content clarity, instructor availability, the amount of time invested in the course, perception of improvement in skills amongst others like personal choice of content and suggestions for improvement along with permission from the participants to be interviewed via telephone. The data was collected from these participants after their consent to the telephonic interviews was obtained. The feedback form was filled by 23 of the 29 participants who completed the course and were awarded the certificates and 3 participants who could not complete the course. Out of the participants who submitted the feedback, 15 conveyed their willingness to be interviewed. The telephonic interviews were conducted within the ethical parameters of research. Neither the data of the interviews, nor their identity or phone numbers were utilized for any other purpose than the purpose of interviews.

3.5 Data Analysis:

The data obtained from the telephonic interviews was documented. The documented data was appropriately coded and further analyzed as per the guidelines of qualitative research (Creswell, 3rd Edition). The narrative analysis was carried out manually for the purpose of identifying codes. The codes were subjected to repeated cycles of coding, filtering, and categorization resulting in respective emergent themes discussed in the next section.

4. Results and Discussions

The analysis of the interview transcripts gave insights into the perception of the participants towards the curated OERs used as major course content. The analysis probed to gain insights on the interactivity and engagement with the OERs augmented on the basis of the LCM model.

4.1. Perception towards curated OERs as course content

The participants mentioned that the concept of curation was a novel idea for them. Most of them revealed that the introductory video by the instructor that spoke of curation motivated them to join the course since they thought curation of OERs would take away the burden of creating videos for their courses. The participants disclosed that they were not well aware of the process of curation. They indicated that curation is a deeper process than just sharing the references.
“Curation would enable me to take up developing my own course which I was putting off. I was worried about the number of videos I would need to create.”
“I never thought this (Curating content) could be done! I mean, we do have quite a few films and videos that we can use.”
“I used to give links of good videos and films to my students to watch. And then struggle to make videos on the same topic again. They are quite dull in comparison. Now I know I need not do it! I feel empowered!”
“I wonder why this is not spoken of when they train us for developing online courses. This makes developing online courses seem do-able.”
“This - that we need not prepare all the content ourselves, was sitting right there, staring in the face, but with this course, I came to know how to build a course using these resources.”

The process of Curation was recognized as a process of deeper thought process and strong pedagogy. The interviewed participants affirmed that the course helped them to understand curation is not just putting resources or giving them as references but it is a more structured way to weave the content. They insisted that the principles of curation gave them the basics of curation and that they could attempt trying curation.

“Curation is not just putting random resources together. I will have to think of the gap in the content before figuring out the next resource.”
“Curation also will mean that I need to have my activities designed and in place.”
“This is serious business. I can’t casually pick up resources that I come across. I need to pick and choose ones which fulfil the objective.”

4.2. Augmenting the OERs on LCM model

The participants expressed that the structure of the course was unique and they had not found a similar structure in the courses that they had taken earlier. The LCM wrappers were found to be useful by the participants. The participants expressed the high level of interaction of the instructor with the participants was unique and kept them motivated. They communicated their views on the elements of the LCM model incorporated in the course.

- Learning Dialogues (LeD) and adding the Reflection Spots (RS)
  The video resources were the most preferred type of resource for both purposes - content and convenience. The participants interviewed noted the marked difference between a shared video resource and the video augmented with a Reflection Spot. The participants interviewed expressed that adding Reflection Spots to the curated OER or created video content and converting them to Learning Dialogues (LeD) addressed their concerns while using video content. The major concerns conveyed were the lack of dialogue between the instructors and their learners and whether the learners are actually watching the content.

  “The concept of Reflection spots and LeDs is a good one. It would be helpful for me to know if my learners are watching the content.”
  “I enjoyed the Reflection Spots that were created using H5P in this course. I am surely going to use it in my course.”
  “I have the habit to ask questions during the class. For me, it tells me whether I need to go slow, repeat something and much more. I always felt that this aspect was missing in the videos that I shared. Now I seem to have found a way.”

- Learning by Doing (LbD)
  The interviewees asserted that the activities such as quizzes and H5P interactive content after the LeDs prompted them to apply what they had learnt. They disclosed that the assignments were application based and consolidated their learning. They affirmed that they were engrossed in the activities through the course and particularly enjoyed the activities
designed using H5P.

“H5P was great. It made the **activities very engaging**. The other courses undertaken did not have such a variety of activities”

“The options in H5P were different from the other courses that we had taken earlier, which included only quizzes.”

“The inclusion of Wiki was a novel idea. It was difficult initially, but I got the hang of it.”

**The benefits of the Discussion Forum (DF) for Learner eXperience Interaction (LxI)**

The interviewees reported to have benefited from the Discussion Forums (DF) and the Learner Interaction (LxI) the most. They expressed that DF helped them to be updated with the course happenings as well as served as the channel for direct contact with the course instructor. As learners, they introduced themselves and disclosed that this assured not feeling isolated in the course. They reported that the different categories of the DF kept the things handy and clutter free. The DF logged the maximum activity. The range of posts for a particular discussion topic began with 15. It was observed that these posts by individual participants were meaningful and carefully drafted ensuring non repetitive points and opinions for discussion. They mentioned that the Focus question ensured that they were prompted to participate.

“The focus question was a very good way to **focus on the content and also dig deeper**.”

“The categories made it very easy to ask our queries. There was always someone or the other to help with the queries.”

“This idea of having a Focus question weaved around the content is an idea that we educators have but I have not seen in practice in the other courses that I have taken. This probably is the **course design**, and I must say, it is **well framed**.”

Additionally, the messenger of the Gnomio Platform was also used by the participants and the instructor for one-to-one communication when needed.

**The trajectories and the diversity**

The interviewees found trajectories (LxTs) to be a unique component of the course. The interviewees recognised that this component was missing in the other courses taken earlier or if present, was not as well structured. They mentioned that the LxTs not only gave them the choice of media for learning but also instigated them towards learning more and in different directions as indicated by the responses.

“I had never come across the concept of trajectories earlier. This was good. I will incorporate it in my course.”

“The trajectories were a new concept. It sparked my interest to further explore related to the topic.”

“I was very concerned about the diversity in my classroom and also the diversity in learning. I think the Trajectories would help address my concerns in the course that I develop.”

**4.3. Engagement with the curated and augmented OERs**

The interviewees reported that they were effectively engaged with the curated and augmented OERs and that they did not feel the absence of the instructor. Some of them recognised that videos by experts in the respective field are much more effective than an instructor. They also appreciated the augmentation and interactivity brought into the curated videos using tools and activities. They recognised that this allowed the instructor to focus on the activities which were contextualized and engaging. They reported that they would try to apply this in their courses.

“The **activities around the course content kept us engaged**. Be it crossword or puzzle for game-based learning or any other activity, there was no repetition.”

“I loved the drag and drop activity and the games. The activities were **relevant** to the content and the objectives of the course.”
“All the activities kept me engaged. And I loved the assignments. It was where I could apply learning of the course to my classroom.”

“The instructor’s presence was felt through the activities and the interactivity in the videos.”

“I did not fast forward any of the videos even once. Because I wanted to answer the questions that popped up in between.”

The most surprising interview responses were that the participants liked the absence of LIVE sessions. They revealed that this relaxed them from the fear of missing out.

‘It was good not to have LIVE sessions. It adds to my stress to be able to make yourself available for the session. Also, in case, if the live session is missed, it usually leads me to stress out with ‘Fear of Missing Out (FOMO). It adds to my demotivation.’

‘A live session might be needed for entry level courses. That also if it is a highly technical course. In the case of advanced learners, a LIVE session is unnecessary. Good that it was not there in this course. In fact, its absence was a relief. Though we would have loved to see the instructors, it would not have contributed to the learning.’

5. Conclusion

The authors were expecting some comments about the lack of indigenous videos in the overall course content; however, the feedback shows that the participants did not record any preference of instructor made videos over the curated ones. They have in fact appreciated the expert videos. The study indicates the need for the training of the faculty members for the process of curation which could enable them to use the OERs.

The study registered favourable responses from the participants towards the LCM wrappers used to augment the course with curated OERs. They highlighted that these elements of the LCM model helped them to be engaged with the course content. The novelty and relevance of the activity are the deciding factors for engagement of the learners. The videos and interactive components remain to be a preferred component of the online courses. Interactive content, using H5P, was highly appreciated by the participants. It underlines the need of interactive material for engagement. Novel ideas for collaboration like a wiki, was appreciated but was found to be difficult and hence not attempted by all. The interviewees reported that the LbDs - the activities did not overwhelm or burden them, instead they were found to be supportive of learning. Nevertheless, participants registered preference for activities that have convenience of access.

Asynchronous but continuous, relevant, interesting communication in the form of Discussion forums and other collaborative activities are adequate to enhance a conducive learning environment especially if the participants are not entry level participants. The dislike towards Live sessions signals towards asynchronous interaction being convenient from the point of view of learners. More research is needed to probe into the finer nuances of this aspect.

A very robust Learner Interaction (LxI), both general and focused with respect to the course topics is helpful in building a learning community. The instructors have to ensure that the DF is kept lively, interactive and quick responses help in sustaining the interest in the OER based course. The study suggests that multiple channels of communication lend approachability to the instructor. This study indicates the possibility of a democratic learning environment using DF in an OER course conducted in online mode.

The study concludes that the teachers' awareness about use of OER is low. It also shows that the teachers need to be explained that the OER cannot be adopted into their course directly, but after adding learner-centric wrappers as suggested by the LCM model.

6. Recommendations

This study gives certain insights into the participants’ thought processes of an online course that had two major differences as compared to most courses- curated OERs and the LCM model. These insights
provide some recommendations as follows.

The faculty members who are developing online courses:

- should be trained in Curation of OERs. This will enable the faculty members to successfully adopt and integrate OERs, thus serving dual purpose: firstly, reducing the load of creating resources and secondly, to contribute to Open Education Resources.
- should not stop at curation but augment the curated OERs using learner centric models like the LCM model to enhance the engagement with the course.
- should leverage the Discussion Forum for the Learner eXperience Interaction (LxI) thereby addressing and overcoming the isolation felt by participants in online courses.

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Abstract: The lockdown restrictions due to the coronavirus pandemic have resulted in educational institutions moving to remote teaching. Teachers needed to adapt their traditional face-to-face instruction to an online mode. The four week, hands-on workshop titled ‘Transition to Online Facilitation’ was launched under the aegis of National Programme on Technology Enhanced Learning in May 2020 to up-skill teachers with knowledge of technical tools and learner-centric pedagogical strategies. This paper highlights the manner in which design drivers like learner-centricity, immersivity, pertinency and transfer of ownership are embedded into the pedagogy design of the sessions on the Slack Platform. It documents and compares the orchestration of the instructor facilitated session and group-facilitated sessions where participants first experience the features of a tool as a student before using the features as a teacher. The level of adoption of design drivers is analysed. This study identifies three kinds of learner profiles namely, Innovators, Adaptors and Emulators. The research reports the Near Transfer of Learning as there was a high degree of similarity between the instructor facilitated session and the group facilitated sessions.

Keywords: Teacher training, ICT integration, Learner-Centric MOOC Model, Active learning, Immersivity, Pertinency, Transfer of Ownership, Collaboration

1. Introduction

To ensure that learning continues despite the lockdown imposed due to the pandemic, teachers who delivered instruction in face-to-face mode in brick-and-mortar institutions have had to engage in emergency remote teaching. The Pan-India lockdown began towards the end of March 2020 which was midway through the academic year. Apart from having constraints of bandwidth and access to gadgets, teachers who prior to the pandemic had limited use of multiple technologies, needed to adapt quickly to online teaching by learning features and pedagogical affordances of various technology tools.

In order to cater to this need and increase technology integration in teaching practice, a pilot workshop on ‘Transition to Online Facilitation (TOF)’ was launched under the aegis of National Programme on Technology Enhanced Learning (NPTEL) in May 2020 and spanned across four weeks. The workshop was conducted for educators from different geographical regions across India who were shortlisted from a pool of applicants. The workshop was structured around hands-on activities and encouraged learners to reflect on practices and tools they learnt and applied. During the workshop, learning was channelized through Slack, a channel-based communication platform developed by Slack Technologies.

This paper documents the process, design elements and the outcomes of the teacher training conducted through the Slack platform. We begin with a brief review of related work on design drivers used in developing professional development programs. Next, we present an outline of the Pedagogy Design based on the design principles of learner-centricity, immersivity, pertinency and transfer of
ownership and elaborate on its implementation. The paper also describes an evaluation rubric used to measure the design and orchestration of training sessions conducted on Slack. Further, the paper analyses the data mined from the communication platform to gauge participation level during the training session. The analysis of training sessions have helped in the identification of three learner profiles, namely, Innovators, Adaptors and Emulators. The characteristic features of these learner profiles are also presented. The insights gained during this study provide inputs to develop training programs for professional development in general and in particular refine the design of the next iteration of training using a communication platform like Slack.

2. Related work and background

For the teacher training to be pertinent, it needs to be in sync with what participants believe they can apply to their own job context (Uysal, 2012). Course designers need to keep this into account while designing faculty development programs. Due to the Coronavirus pandemic, teachers had to resort to usage of multiple technologies to engage classes and needed to be trained in this regard.

Learning to use ICT can be relevant and effective when it is centred on ‘meaningful learning activities’ involving technology (Howland, Jonassen, & Marra, 2012). Several studies on effective ICT integration in Teacher Professional Development recommend designing immersive, student-centric experiences for participant teachers where they can first engage with the content and can experience using a technology as a student (Banerjee, Murthy, & Iyer, 2015; Howland, Jonassen, & Marra, 2012). Including transfer of ownership from the instructor to participant teacher ensures that technology integration is the onus of the participant teacher (Warriem, 2018).

There are models for learner-centric course design that recommend immediate practice after introduction of content (Murthy, Iyer, & Warriem, 2015; Murthy, Warriem, Sahasrabudhe, & Iyer, 2018; Warriem, 2018). The Learner-Centric MOOC (LCM) model “consists of a set of guidelines which help in conceptualizing, creating and conducting” a course and addresses the problems related to lack of learner engagement (Murthy et al., 2018). This model includes components called Learning by Doing (LbD) activities where participants get immediate practice on the concept that is being introduced and receive customised feedback and Learner eXperience Interactions (LxI) where a focussed discussion facilitates peer learning and encourages participants to reflect on their learning.

Critical enquiry is beneficial in enhancing one’s own teaching practices (Norton, 2019). When participant teachers go through this experience, they are encouraged to reflect on their own usage of technology in teaching practices in order to increase their students’ learning outcomes.

Training activities on Slack were operationalized around the design drivers of learner-centricity, immersivity, pertinency and transfer of ownership as these factors enabled participants to experience the technology tool first as a learner and then create learning experiences based on various tools. This enabled Near Transfer of Learning (Woodworth, R. S., & Thorndike, 1901).

3. Our solution

The workshop focused on teacher training and community building through Slack and its integrated features. This section documents the manner in which the design drivers were integrated and implemented in the sessions on Slack.

3.1 Implementation of the solution

An introductory session on ‘Using Slack on Slack’ was designed in order to model the use of Slack as a teaching-learning tool. The objective behind this approach was to allow the participants to experience using Slack as learners and then as instructors. This session was conducted by the instructor and was moderated by the Teaching Associates (TAs) of the workshop. See Figure 1.
The session was designed to be useful for participants accessing Slack in a synchronous as well as asynchronous mode. It adopted components of the LCM model (Murthy et al., 2018). The session also included Think-Group-Share, an active learning strategy and a curated set of resources. Participants responded to questions, answered polls and reacted to the posts using different kinds of reactions. The process of responding to posts and answering queries by fellow participants were gamified. After participants posted their responses, the instructor included ‘facilitator summary’. Further, the instructor obtained participant feedback and introduced participants to group facilitation tasks.

After experiencing Slack as a learning platform, participants collaboratively worked in groups to choose a technology tool and facilitate a session using Slack. The tools ranged from technologies used in content curation, content creation, collaboration and assessment. This model for training was employed so that participants could immediately apply and adapt the techniques they experienced during the session on Slack. Participants were divided into ten groups and each group had a participant moderator. The participants were chosen as ‘Community Discussion Forum Moderators (cDFMs)’ on the basis of active performance and participation in the workshop Discussion Forum. The cDFMs were guided by the instructor and TAs on collaborative learning and community building. Further, in order to incentivize participants, 30% of the total course grade was based on the activities in Slack. Participants needed to attend at least two of the group facilitated sessions.

### 3.2 Utilizing Design Drivers for the solution

The design drivers for the introductory instructor-facilitated session on ‘Using Slack on Slack’ were: Learner-centricity, Immersivity, Pertinency and Transfer of ownership. The group-facilitated sessions reflected these design drivers in various degrees.

#### 3.2.1 Learner-Centricity

The sessions incorporated components from the LCM Model. The instructor used focus activities to guide participant discussions on particular aspects of online teaching- learning and communication tools. Think-Group-Share, an active learning strategy was employed to encourage introspection on teaching practices and facilitate peer learning. See Figure 2 where the cDFMs referred to as group leaders facilitated and moderated discussions related to the activities.

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**Figure 1: Pedagogy Diagram of Sessions on Slack**

<table>
<thead>
<tr>
<th>Roles during the instructor facilitated session on Slack</th>
<th>Features used</th>
<th>Step-wise tasks by instructor, TAs and participants on Slack</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructor</td>
<td>Chat, Polls</td>
<td>1. Instructor conducts the session and posts questions for focused discussions related to features and pedagogy of tool</td>
</tr>
<tr>
<td>TAs Video Conferencing Tool</td>
<td>All features</td>
<td>2. TAs moderate the session; document the session</td>
</tr>
<tr>
<td>Participants</td>
<td>Chat, Polls</td>
<td>3. Reply to questions with threaded posts and reactions; post doubts</td>
</tr>
</tbody>
</table>
The instructor invited the cDFMs or a representative from the group during the session to share the points that were discussed in the private groups channels to all the participants. The session included a summary for each activity, where the instructor highlighted key points, summarised the discussions and closed the loop in a post. See Figure 3.

The activities were designed in such a way that it provided learners with an opportunity to immediately explore and practice various features of Slack. While participants were asked to reflect on their teaching practices, they needed to share their thoughts through Slack’s thread feature in chat, and in private channels. In addition, they could explore reaction features as well as the features of the apps that were integrated into Slack like Polls and Jitsi. These LbD activities were accompanied by constructive feedback in the synchronous session that was provided by the Instructor and TAs.

3.2.2 Immersivity

The format of the introductory session on Slack was high on immersivity. As per the immersivity principle, through a series of guided instructions, participants were immersed in exploring various features like posting in a thread, using group channels. This learning by doing increased the level of immersion as participants could experience using Slack as students where they discovered various features and engaged in discussions with their peers based on the focused questions.

Then in group-facilitated sessions they needed to facilitate similar sessions on any technology tool, based on the design drivers used. The group facilitated sessions also reflected this immersivity principle as participants could discover features of tools as learners through a series of reflection questions and activities.

Once learners witnessed how to conduct a session on Slack from the instructor, they applied similar techniques and design drivers in the group sessions that they facilitated. In the group facilitated sessions, the facilitators followed the pedagogical design seen in Figure 1. Near transfer of learning could be observed as the Slack training session and the trained behaviour are similar to that emulated by the participants in the group facilitated-sessions.

3.2.3 Pertinency

The design drivers of pertinency were woven into the choice of the communication tool for conducting
the session as well as the kind of questions used for focused discussion. The free version of Slack with its multiple features and integrated tools to facilitate discussions, collaborations, track learners activity would be appealing to learners (Ross, 2019). As compared to Google Groups, this channel-based messaging platform has a more vibrant User Interface which would be appealing to students. Unlike Whatsapp, and similar to Telegram, it is a cloud-based tool that also enables users to keep certain information private.

During the instructor facilitated session, through a series of focus activities, participants needed to reflect on how they used various communication tools during the lockdown while teaching. See Figure 2. As in a class, where active learning strategies are implemented, participants brainstormed with each other in their group channels and posted summaries in the main training channel. Group leaders could take charge of facilitating the discussions in their groups.

According to the design principle of pertinency, participants would need to generate artefacts for their own context. After the instructor's session on using Slack, the group-facilitated sessions on Slack are artefacts of the course. The manner in which groups have integrated design drivers shed light on the degree of adoption.

While the group leaders played a major role in rallying their teams to plan and facilitate the session, a shared sense of responsibility was observed among the members of the group. Different members took on ownership of various components required for the session like designing announcement, content and questions for the session, feedback form, etc. At the end of the group sessions on various tools, the participants in turn needed to create an artefact based on the tool for their own courses.

### 3.2.4 Transfer of Ownership

During the instructor-facilitated session, the transfer of responsibility of driving discussion in the group to designated cDFMs was a driving force behind interactions. See Figure 2. Having smaller group discussions also ensured that those intimidated by larger groups also participate. Apart from initiating discussion in their groups, the cDFMs were tasked with the responsibility of on boarding the groups mates onto Slack, providing constructive feedback to their team based on various course activities. Group members were simultaneously encouraged to add to the comments given by the cDFMs.

After the instructor-led session, the ownership of conducting further sessions on technology tools shifted to the groups. Each of the ten groups conducted at least one session over the course of two weeks. They could choose any tool of their choice and they needed to conceptualize the session, curate and create resources.

### 4. Research method

The research question that this study attempts to answer is: What aspects of the instructor facilitated session on Slack did participants emulate in their collaborative session on tools during the workshop? To answer this research question, we have used a mixed-method study to evaluate the training sessions on Slack.

#### 4.1 Sample

A total of 200 participants from various educational institutions across India registered for the pilot run of the workshop. Out of 160 participants who joined Slack, 86 were active participants. Active participants are those who have posted at least once or have reacted at least once in the public channel of Slack.

#### 4.2 Instruments used

We used a variety of instruments to collect data on actual engagement in the training and adoption in
the training. To gain an understanding of the rate of participation and engagement, we analysed the data from the public channel of Slack where the training sessions were conducted. To ascertain the level of adoption of aspects in group-facilitated sessions, we used a design and orchestration rubric.

5. Results

We have used the data mined from the Slack to observe the level of participation during the training sessions. At the basic level, this data is reflective of the workability of the instructional strategies employed during the training sessions on Slack. In addition, we present an evaluation rubric employed to perform qualitative analysis of the training sessions.

5.1 Quantitative analysis

During the workshop, a total of ten group sessions were conducted by the participants on Slack. On certain days, multiple group training sessions were conducted. However, to spot the trends in the learner participation and engagement during the sessions conducted on the Slack, we focussed our analysis only on the days when a single session was conducted. Group 5 volunteered to conduct the first collaborative participant-facilitated session on 31st May 2020. Mid-way through the training, Group 4 conducted their session and Group 9 facilitated a session on the last day of the training.

The data presented in Table 1 is based on the data obtained through the ‘Analytics’ feature of Slack. The data obtained from the public channels of Slack was further processed to dig deep into the participation level. Table 1 presents three attributes, namely, the number of posts, replies and reactions which are being used to gauge the level of participation on the days of sessions. Figure 4 graphically presents the day wise data of number of posts, replies and reactions for the entire period when training was conducted on Slack.

<table>
<thead>
<tr>
<th>Date of Session</th>
<th>Group Number</th>
<th>Session Description</th>
<th>Posts</th>
<th>Replies</th>
<th>Reactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 27, 2020</td>
<td>-</td>
<td>Using Slack on Slack*</td>
<td>19</td>
<td>35</td>
<td>458</td>
</tr>
<tr>
<td>May 31, 2020</td>
<td>5</td>
<td>Google Classroom</td>
<td>17</td>
<td>110</td>
<td>161</td>
</tr>
<tr>
<td>June 2, 2020</td>
<td>4</td>
<td>Audacity</td>
<td>43</td>
<td>112</td>
<td>224</td>
</tr>
<tr>
<td>June 6, 2020</td>
<td>9</td>
<td>Audio FM</td>
<td>27</td>
<td>28</td>
<td>58</td>
</tr>
</tbody>
</table>

*The session on ‘Using Slack on Slack’ was conducted by the instructor.

The session facilitated by the instructor saw 19 posts, 35 replies and 458 reactions. Out of the three session days shortlisted for analysis, the highest activity in terms of number of posts, replies and reactions was seen for the session conducted by Group 4. The sessions conducted by the instructor recorded a relatively low number of replies but the highest number of reactions in the public channel. This was due to the fact that during the instructor-led session, some group activities involved participants posting and having discussion in their private group channels that were created by the instructor rather than the public channel. Only data generated from the public channel on Slack can be tracked. The cDFMs had to summarise points discussed in their own private channels and reply to the instructor’s post. As indicated in the polls taken for attendance, 51 marked that they attended the session synchronously or asynchronously. Participants used the reaction feature of Slack to reply to the instructor’s group activity post as the instructor wanted them to only post in the private groups for those activities. The participants-facilitated sessions on the other hand didn’t require attendees to work in groups.
5.2 Qualitative Analysis

The group sessions were evaluated qualitatively based on a rubric which was designed by taking the introductory session conducted by the instructor as a benchmark.

Table 2: Rubric for the evaluation of Design and orchestration of Group sessions (N=10 groups)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Target</th>
<th>Satisfactory</th>
<th>Inadequate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of application of design drivers of Immersivity, Pertinency and Transfer of ownership</td>
<td>Effective application of design drivers (4 groups)</td>
<td>Acceptable application of design drivers (4 groups)</td>
<td>Very limited application of design drivers (2 groups)</td>
</tr>
<tr>
<td>Learner centricity of instructional strategy based on LCM principles</td>
<td>Instructional strategy employed majority of LCM principles (8 groups)</td>
<td>Instructional strategy employed some of LCM principles (2 groups)</td>
<td>Instructional strategy employed none of the LCM principles (0 group)</td>
</tr>
<tr>
<td>Orchestration</td>
<td>Tasks presented in a timely manner, sufficient time given to perform various tasks, queries from participants answered. Efficient use of technology for delivery of content and</td>
<td>Most tasks presented in a timely manner, sufficient time given to perform most of the various tasks, most of the queries from participants answered. Adequate use of technology for delivery</td>
<td>Tasks presented in a haphazard and uncoordinated manner leading to confusion among participants. Inadequate use of either too few or too many technology tools and platforms for delivery of</td>
</tr>
</tbody>
</table>
engaging participants (6 groups) of content and engaging participants (4 groups) content and engaging participants. (0 group)

**ICT Integration**

The group employed innovative ways for ICT integration during the session. For example, use of Slack features for TGS activities, Wordpress with interactive activities (4 groups)

The group used a wide range of ICT for useful but standard tasks. For example showcasing submission of artefacts, Demo videos (5 groups)

The group used only video conferencing tools to deliver sessions. (1 group)

From Table 2, we can infer that:

- 40% groups effectively applied design drivers of immersivity, pertinency and transfer of ownership.
- Majority of the groups have consciously used learner centric principles while designing their sessions.
- Most of the groups orchestrated session activities efficiently.
- 40% groups used innovative ways of ICT integration during their session while 50% groups primarily used ICT resources for performing standard tasks.

For deeper analysis, we focus on content analysis of the collaborative sessions conducted on the days when a single session was conducted i.e. session conducted by Group 4, 5, 9. The sessions included a number of components. To illustrate the similarity and difference with the participant-led sessions and the instructor-led session, the kinds of posts were analysed and three common types emerged.

- **Polls**
  The instructor introduced interactive polls during the session as a means for recording attendance. While Group 5 made use of polls in a similar manner, Group 4 displayed innovativeness by designing their session around the multiple interactive polls. A pre-session poll activity was conducted to elicit responses. During the session, polls were used to gauge participant engagement and to obtain feedback of session activities. Group 9 exhibited similar use of polls as displayed in the prior sessions.

- **Facilitator Summary**
  During the session the Instructor summarized each activity. While Group 4 built on the type of facilitator summary and added analysis of kinds of replies by participants, Group 5 provided only an end of session. Group 9 did not include this feature in their session.

- **Learning by Doing**
  The instructor introduced features of Slack through LbD activities to provide an immersive learning experience. All three groups used this feature and included activities where participants needed to put the features of the respective technology tool into practice. Some groups also included metacognitive questions as LbD. Constructive customised feedback was provided during the synchronous session on Slack. Some groups extended this and provided feedback asynchronously till a particular due date.
6. Discussion

The results of this study shed light on the level of adoption of design drivers and strategies used in group facilitated sessions. Based on the analysis of sessions facilitated by the group members on the Slack, we have identified three learner profiles.

- **Innovators** - It is apparent that for the session conducted by Group 4, the group facilitators took inspiration from the instructor led session and employed innovative strategies to enhance learner engagement. This category of learners is identified as ‘innovators’ as they improvised their instruction style with a balanced mix of activities and pedagogical strategies which lead to innovation. The activities and learning path that was designed by them helped to enhance participant engagement, motivation and attainment through the session.

- **Adaptors** - Group 5 adapted the instructor’s style of engaging the learners during the session. Unlike the instructor-led session, this group utilized their Wordpress site as an additional platform to share resources with the participants. Like the instructor-led session, certain group members performed the role of the moderators to handle queries during the session. This category of learners adapted their instruction by modifying the activities and engagement strategies that they designed for the session. The session activities were similar to but not an exact replica of the strategies followed in the session conducted by the instructor.

- **Emulators** - Group 9 emulated the instructional style followed by the instructor as well as embraced the style of instruction of other groups. This category of learners replicated the learning pattern and pedagogical techniques learnt through the prior sessions.

7. Conclusion and Future Work

The idea discussed in the paper about providing an immersive learning experience and then offering opportunities for applying what is learned, is an important principle while designing Faculty Development Programs with the use of Technology. Hence, the Pedagogy Design and Rubric attempt to showcase that when participants are trained to use the technology as learners and then are able to practice it as instructors, the affordances of technology are properly used. The Pedagogy Design and accompanying rubric have three primary functions:

- to facilitate ‘learner-centric’ practices in design and development of training programmes,
- to facilitate orchestration/operationalization of training with demarcated tasks to course instructors, TA’s and DFMs,
- to provide feedback to instructors about the level of performance of participants given the course design choices made.

Using the rubric provides information beyond that available from the Slack Analysis tool. The Slack Analysis tool provides data about the quantity of interactions such as number of threaded posts, reactions and so on. The rubric taps into participants’ intellectual efforts, skills, performance, and
participation. Further, using the design and orchestration rubric for Group sessions, it is observed that different profiles of groups emerged. However, from these groups, further analysis of individual data logs is required to be able to identify individual innovators who can assist in further developing professional learning activities.

In addition, a larger and more diverse sample size would enable us to make more generalised conclusions. There is also a need to assess participants’ individual course journals to be able to accurately characterize them and get a better indicator of behaviour involved. Rubric further needs to be validated and inter-rater reliability needs to be established.

Acknowledgement

The authors acknowledge the support of Dr. Jayakrishnan M who has mentored them in the orchestration of the sessions in Slack. The authors thank the National Programme on Technology Enhanced Learning (NPTEL) for providing the support in the training program. The authors also acknowledge the support of Mr. Nirav Pansuriya in the data analysis from Slack. The authors would like to express gratitude to TEQIP III project, Educational Technology Department, IIT Bombay for financial support.

References


Using Guided Roles in Virtual Forum as a Strategy for Empowering Students’ Participation in Online Classes: A COVID-19 Response

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Abstract: This paper illustrates the use of guided virtual forum as a teaching strategy for empowering students’ participation in online classes. The design of the virtual forum was derived based on the principles advocated by flux pedagogy, focusing on teaching design that are adaptive and responsive to the impact of COVID-19 on teaching and learning norms. The purpose of the virtual forum was twofold. First, as an online activity for the students to learn about the course’ subject matter in interactive ways. Secondly, the purpose was to empower and encourage all students to participate in online classes from behind the screen. The survey results show positive feedbacks from the students who participated in the virtual forum; reporting learning gain from both the content (subject matter learned) and process (increased in skills and confidence levels).

Keywords: Virtual forum, online teaching strategy, flux pedagogy, online participation, student engagement

1. Introduction

Due to the COVID-19 pandemic, life has become an indefinite state of flux with unprecedented concerns involving the global health, life uncertainties, as well as disrupted routines and changing norms. Since in-person teaching and classes became a non-viable option, the outbreak has since disrupted and altered the landscape of teaching and learning among the education community. As noted by Ravitch (2020), this global moment requires educators to learn a set of new skills for designing and enacting humanize and transformative pedagogy with the students as we teach them specific content areas.

Teaching and supporting learning during pandemic COVID-19 is an unknown territory for most members of the academic community. With universities being abruptly closed and academics are suddenly expected to teach remotely, how do academics adapt and transform their teaching practices and approaches into online and digital spaces without compromising on the students’ learning experiences and outcomes?

This paper presents an online teaching technique that was used for facilitating and empowering students’ participation while learning about a subject matter during an online class. This paper is built upon the perspective of flux pedagogy as elaborated by Ravitch (2020), referring to an inquiry-based, emergent teaching design that integrates relational and critical pedagogy framework into a transformative teaching approach in times of crisis or flux situation.

2. Flux Pedagogy

The term “flux pedagogy” was coined by Prof. Dr. Sharon M. Ravitch (2020) to refer to the transformation of teaching approaches in times of radical flux through the integration of relational and critical pedagogies. The word flux itself describes something that constantly changes. When faced with
sudden changes such as those impacted by the outbreak of COVID-19, flux pedagogy advocates for teaching approaches that are adaptive, generative, and compassionate.

Flux pedagogy entails six primary dimensions as follow:
1) Trauma-informed pedagogy;
2) Emergent design, student-centered, active teaching;
3) Inquiry as stance;
4) Critical pedagogy;
5) Racial literacy pedagogy; and
6) Brave space pedagogy

In specificity, the teaching strategy discussed in this paper is scaffolded by the principles elaborated from the second dimension, based on emergent, student-centered, and active teaching principles. In a flux situation, this dimension calls for co-creation of a learning environment that is supportive, active, responsive, and contextualized. Instructors are asked to engage in active listening and perspective-taking with their students, and adapting and replanning their classes while taking into consideration the impact of the current crisis on the students (Ravitch, 2020)

3. Student Engagement and Online Participation

A major flux that the students faced while learning during pandemic COVID-19 was the socio-environment shift in their learning context. With classes being held fully online, it requires the students to immediately adjust to the changing social dynamics and interactions between their classmates and instructors. As classes no longer take place in a physical, face-to-face environment, the experience is no longer the same as context of learning is highly influenced by the mode of delivery (Westera, 2011). As noted by Westera (2011), digital media tend to bring about new dimension of context and thus, requires reconsideration of the learning context.

The differences between in-person and online classes have been acknowledged by Wua et al (2008). The authors contend that instructors must seriously think how to redesign learning delivery that uses new technological capabilities that are of different nature than the previous technological knowledge, such as those in face-to-face delivery. Respectively, this implies that instructors must continually seek to be creative and innovative in their teaching design and approaches especially when the teaching medium or context has changed.

One of the major challenges in online teaching is to sustain student engagement and encourage their active participation while learning online. Cole and Chan (1994) described student engagement as “the extent of students’ involvement and active participation in learning activities (p. 259). Engagement takes place on a continuum and is contingent to several degrees of involvement (Avendano, 2003). Therefore, academics must play the important role of designing courses that encourage interaction, participation and communication in their online courses in order to promote higher level of engagement from the students (Johnson, 2003; Weiss et al., 2000).

4. Online Learning Activity using Guided Roles in Virtual Forum

4.1 The Course

The course taught was a postgraduate course for Principles of Adult Education subject. The course caters to primarily postgraduate students in the Human Resource Development program. The coursework for this subject was planned and structured for 14 weeks of face-to-face classes (one semester duration). However, the regular classes was disrupted during Week 5 due the Movement Control Order (MCO) that was implemented during the COVID-19 global crisis back in March 2020. After several weeks of MCO, classes were asked to be taught fully online in order for the semester to proceed.

In order to redesign the class delivery and learning activities, the instructor conducted a simple survey to gauge the students’ readiness to learn online. The total students enrolled in this course was
33, although only 29 students responded to the survey. Majority of the students was not accustomed to attending classes online and have to adjust to the new learning environment (93.1%). However, majority of them reported that they are absolutely prepared or will get themselves prepared (96.6%) to attend classes online. In terms of online class delivery, majority (48.3%) prefer a combination of both synchronous and asynchronous classes throughout the remaining semester. Based on these insights, the instructor started to redesign the class delivery and activities structured based on the course contents.

The online class was taught using Zoom as the online platform. After the first two weeks of resuming classes online, the instructor noticed the key challenge faced was the absence of online social presence and two ways communication during the synchronous (real-time) class. When prompted for feedback or answers from the students during online lecture, responses received were either none, or lapse and short-lived. The lively interaction that was observed during the first few weeks of in-class teaching could not be replicated the same way. Online participation among the class members were also unbalanced; only a small pool of students were willing to unmute their microphone and speak, whereas some felt more comfortable writing their responses in the Zoom Chatbox. Majority of the of the class members however, were silent or noncommunicative. Since the instructor attached “Class Participation” as one component of the class evaluation, she felt like some students might missed out on the learning activities conducted during the online class. This inadvertently and eventually may affect their class participation assessment at the end of the semester.

4.2 Virtual Forum

In distance, online and blended learning context, the term forum typically refers to asynchronous online discussion (AOD) among the class members that takes place in a virtual environment (Ithindi, 2013; Lonkar, Barrett, & Liu, 2014; Thomas, 2002; Thomas, 2013). Most online forum discussions were conducted through or on Learning Management System (LMS) platforms (Lonkar, Barrett, & Liu, 2014). However, in this paper, the forum activity was carried out in synchronous setting using Zoom, and involved pre-planning and live participation from all registered students in this class (n = 33). The virtual forum was conducted as a learning activity during the course’s online class at Week 8. The topic was predetermined by the instructor so that it is aligned with the course’s learning outcomes (LO), titled “Adult learners & adult learning: Post COVID-19 situations”.

The activity was called Guided Virtual Forum because the structure of the forum was guided by predetermined roles. One week before the forum, the instructor released information about the virtual forum on the course’s LMS. The instructor provided a Google sign-up form for 33 roles, where each student was asked to sign up for a role that they would like to contribute during the forum. In the sign-up sheet, the task for each role was elaborated so that the students are aware of the term of reference (TOR) for the role that they chose to contribute. Please refer to Appendix for the 33 roles that were outlined for this guided forum activity.

The sign-up was on first come first serve basis. The following message was also shared to the class in order to build the class’s understanding on the purpose of the virtual forum activity:

This activity is designed to encourage online interactions from all the class members. The goal is to start familiarizing everyone to a new normal of attending virtual class. Therefore, everyone in this class must contribute in their own ways, and cannot constantly be passive from behind the screen. Otherwise, in the future, your presence in the class might not be noticed by the instructor. Social presence is really important in recognizing your class participation as it is part of your course assessment. Now that classes are unable to take place in a physical space, it’s important for students to know how to contribute your social presence in an online context.

4.3 The Implementation

The guide their preparation for the forum, the class was provided with one reading (see Boeren, Roumell, & Roessger, 2020) and divided into seven groups (based on their existing grouping from the class’s assignments). There were seven questions that were posed as subtopics that each group will need to pre-prepare and answer during the virtual forum, outlined as follow:
1. In general, how are adults affected by the Covid-19 situation? In Malaysia? Asia? Across the world?
2. What are the key challenges that will be faced by adults during post Covid-19? Please share at least 2 points.
3. What kind of new normal that adults will be expected to adapt in post Covid-19 situation? Please share at least 2 points. Can all groups of adults adapt to these new norms?
4. What important roles do adult education play post Covid-19 situation? Please share at least 2 points.
6. What kind of policy (either company or government policies) can be proposed to help adults adapt and recover during post Covid-19 situation? Please share at least 2 suggestions.
7. What are the key lessons and future of adult education in post Covid 19 situation? Please share at least 2 points.

During the virtual forum, the above questions were answered and responded by students who were assigned as panellists. To ensure there are some interaction and two way discussions during the forum, there were also audio commenters assigned to respond to the discussions presented by each panellist. The overall virtual forum was moderated by two students who take on the role of moderators, while the technical aspect of the forum was administered by the technical moderator.

To cater for different learning and communication styles among the class members, the instructor also prepared several roles that can be fulfilled through text-based communication. As she noticed some students prefer to respond via Zoom Chat and some were introvert communicator, several roles such as scriptwriter, chat moderator, chat commenters and note takers were also provided as part of the virtual forum ecosystem.

The key role in ensuring the successful conduct of this forum was pinned on the role of the class’s representative who acted as the invigilator during the planning and implementation of the virtual forum. The instructor requested the class’s representative to take on the role as the invigilator. The instructor outlined the invigilator’s role as follow:

The invigilator will be responsible to help and monitor the sign-up and online forum participation from behind the scene. Please be prepared to prompt the assigned person to stay alert & responsive to their assigned roles during the virtual forum. Invigilator will also double as time keeper to ensure that the online forum will not go more than 90 – 120 (maximum).

The invigilator key duties was to ensure that all the roles were assigned and filled by all 33 students, and met the conditions as requested by the instructor (please see Appendix). During the implementation of the virtual forum, the invigilator also played a key role in ensuring that all students participated or responded as per their assigned roles.

The virtual forum took place during the class time as a learning activity. This activity was designed as a strategy to empower the students’ participation in an online class. The guided roles were provided and preassigned to scaffold the planning and implementation of the virtual forum. The administration of the forum was fully led by the students and the instructor only played the role as an observer cum evaluator during the virtual forum. The forum took about 90 minutes in total and was successfully implemented without major disruption or difficulty.

5. Results and Discussions

Upon completion, all students were asked to provide their feedback about the virtual forum activity. A total of 32 out of 33 registered students in the class answered the survey. All but one students reported that this was their first time participating in a virtual forum that is fully students-led (96.6%). Students were asked about their satisfaction level and their perception about the learning that they gained from the virtual forum activity. All students reported that they were very satisfied (62.5%) and satisfied (37.5%) with their own contribution during the virtual forum. As a matter of fact, almost all the students (96.9%) felt like their role is significant and important in contributing to the success of the virtual forum.
All of the students were also satisfied with the learning experiences that they had during the guided virtual forum. Please refer to Figure 1 for an overview of class’s feedback about the guided virtual forum activity.

Some students also shared their written feedback in the survey provided. They reported positive comments about their learning experiences as a result of participating in the virtual forum. The students reported their learning gains both from content (i.e. topic of the forum related to the course’s subject matter) and process perspectives, namely their increased speaking skill and confidence level in learning online.

- **Everything goes smoothly for our first online forum.** Firstly, I learned to express my view and opinion virtually in front of lecturer and classmates confidently. Besides that, I can also learn some new insights from the sharing of my friends in the forum.
- **I can contribute my ideas as an audio commentator** and learn my weaknesses when speaking online. Learn how others delivering their points and focus on their strength to be inspired. Admired others contribution with different roles which they are managed to do perform it very well. This is my first and excellent experience involve in students led online forum.
- **The forum build up my confidence level & become active user of media and technology in learning.**
- **Honestly, at first I have no idea how online class will be conducted.** I prefer to have the normal ways of learning through physical class. However participating in our online class give me new experience and opinion that online class can be so much fun and interactive.
- **This is a great opportunity for us to explore the new paradigm of online learning.** Post COVID-19 situation had bring the education to be conducted online or via distance learning. However, it is throughout this AE class, that we are able to experience different interactive way of online learning (despite the regular one) such as experiencing break out room activities and online forum. Perhaps, we could perform other variety methods of learning in the future.

The overall results showed that the virtual forum activity was successful in achieving its purpose; to empower the students’ participation in online classes while at the same time, learning about the content or subject matter effectively. Several principles of flux pedagogy were also inculcated in the design of the virtual forum; emphasizing on safe climate for learning, reciprocity of efforts from the instructor as well as the students, and a contextualized topic that was based on the current issue (the impact of COVID-19 on adults).
6. Summary and Future Work

Forums, when carefully designed, can be a powerful learning tool to empower and engage students’ learning. This paper reports on a strategy used in an online class using guided virtual forum. Atypical to asynchronous forum discussion (AOD) that are commonly used in online classes, this virtual forum was designed to emulate the real-world forum that took place synchronously after some careful planning and preparation by all the students involved.

The key purpose of this virtual forum was twofold. First, the virtual forum was designed as an interactive online activity for learning about the subject matter in interactive and effective ways. Secondly, the purpose of the virtual forum was to familiarize the students with new norms of learning online, where each student must learn to participate and contribute their opinions from behind the screen. Past studies have reported that development of speaking skills was not the primary strength of online mode of education (Robinson & Hullinger, 2008). However, this paper reports a contrary finding among the students who participated in this virtual forum. In addition to being able to effectively learn about the subject matter, many students reported increased confidence levels in their ability to speak and participate in online classes. Overall, the survey results show feedbacks received from the students were overwhelmingly positive.

Moving forward, the instructor would like to further explore the use of guided virtual forum as a teaching strategy in other classes (for different subject matters and different levels of students), and compile more systematic empirical evidences of its effectiveness as an online teaching strategy.

Acknowledgements

The author would like to thank all her students in DCE5011 who participated in this guided virtual forum activity and completed the survey; which made the writing of this paper possible.

References


## Appendix: Sign-Up Sheet for Guided Virtual Forum

<table>
<thead>
<tr>
<th>Role</th>
<th>Task/Prompts</th>
<th>Sign-up (Name &amp; Matric No.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Master Audio Moderator</td>
<td>Responsible for moderating the online forum. Key tasks: Decide the entire flow of the online forum and facilitate the Q&amp;A discussions between panellists and audio commentors. End the online forum with concluding remarks and key points from the online forum discussions</td>
<td></td>
</tr>
<tr>
<td>2. Second Audio Moderator</td>
<td>Provide assistance to master audio moderator in moderating the online forum. Introduce the panellists, and provide some recap and general comments throughout the session. Will be covering for master moderator if he/she needs to step away from the screen.</td>
<td></td>
</tr>
<tr>
<td>3. Scriptwriter</td>
<td>To assist audio moderators in preparing scripts and write up for the online forum. Scriptwriter will assist behind the scene where she/he can provide scripts to the moderators to read during the online forum, especially when concluding and summarizing the online forum as it is happening live.</td>
<td></td>
</tr>
<tr>
<td>4. Chat Moderator 1</td>
<td>Responsible for monitoring, prompting and responding to chat responses for Q1 – Q3 questions and other general comments asked in the Zoom Chatbox. Will be covering for Chat Moderator 2 if she/he needs to step away from the screen.</td>
<td></td>
</tr>
<tr>
<td>5. Chat Moderator 2</td>
<td>Responsible for monitoring, prompting and responding to chat responses for Q4 – Q7 questions asked in the Zoom Chatbox. Will be covering for Chat Moderator 1 if she/he needs to step away from the screen.</td>
<td></td>
</tr>
<tr>
<td>6. Technical Moderator</td>
<td>Responsible for preparing slides for all the 7Qs, navigating the Zoom shared screen during the guided online forum, and providing technical support in Zoom for panellists and commenters during the online forum (where applicable).</td>
<td></td>
</tr>
<tr>
<td>7. Invigilator / Time Keeper</td>
<td>Will be responsible to help and monitor the online forum participation according to the class assigned roles from behind the scene. Be prepared to prompt the assigned person to stay alert &amp; be responsive of their assigned roles during the online forum. Invigilator will also double as time keeper to ensure the online forum will not go more than 90 - 120 minutes (max).</td>
<td></td>
</tr>
</tbody>
</table>

Note: All panellists MUST provide audio responses to the following Qs during the online forum. The groupings are based on the class’s
<table>
<thead>
<tr>
<th></th>
<th>group assignments. Answers can be pre-prepared together by group members for each group. Please premise your answers based on what you’ve learned and read so far in this class, as well as current information &amp; literature that you can find to support your answers.</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.</td>
<td>Panellist from Group 1 Q: In general, how are adults affected by the Covid-19 situation? In Malaysia? Asia? Across the world?</td>
</tr>
<tr>
<td>9.</td>
<td>Panellist from Group 2 Q: What are the key challenges that will be faced by adults post Covid-19? Please share at least 2 points.</td>
</tr>
<tr>
<td>10.</td>
<td>Panellist from Group 3 Q: What kind of new normal that adults will be expected to adapt in post Covid-19 situation? Please share at least 2 points. Can all groups of adults adapt to these new norms?</td>
</tr>
<tr>
<td>13.</td>
<td>Panellist from Group 6 Q: What kind of policy (either company or government policies) can be proposed to help adults adapt and recover during post-Covid 19 situation? Please share at least 2 suggestions.</td>
</tr>
<tr>
<td>15.</td>
<td>Note Takers 1 &amp; 2 (2 persons) Consolidate and summarize key points from panellists &amp; commenters (from both audio &amp; chats) for Q1 – Q4 Please work together with Note Takers 3 &amp; 4 to come out with a reflection report to be shared to the class later</td>
</tr>
<tr>
<td>16.</td>
<td>Note Takers 3 &amp; 4 (2 persons) Consolidate and summarize key points from panellists &amp; commenters (from both audio &amp; chats) for Q5 – Q7, and overall conclusions from the online forum. Please work together with Note Takers 1 &amp; 2 to come out with a reflection report to be shared to the class later</td>
</tr>
<tr>
<td>17.</td>
<td>Audio Commenter 1 Respond to information/answer provided by Panellist 1</td>
</tr>
<tr>
<td></td>
<td>Commenter Type</td>
</tr>
<tr>
<td>---</td>
<td>-----------------</td>
</tr>
<tr>
<td>18</td>
<td>Chat Commenter 1</td>
</tr>
<tr>
<td>19</td>
<td>Audio Commenter 2</td>
</tr>
<tr>
<td>20</td>
<td>Chat Commenter 2</td>
</tr>
<tr>
<td>21</td>
<td>Audio Commenter 3</td>
</tr>
<tr>
<td>22</td>
<td>Chat Commenter 3</td>
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<tr>
<td>23</td>
<td>Audio Commenter 4</td>
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<tr>
<td>24</td>
<td>Chat Commenter 4</td>
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<tr>
<td>25</td>
<td>Audio Commenter 5</td>
</tr>
<tr>
<td>26</td>
<td>Chat Commenter 5</td>
</tr>
<tr>
<td>27</td>
<td>Audio Commenter 6</td>
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<tr>
<td>28</td>
<td>Chat Commenter 6</td>
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<tr>
<td>29</td>
<td>Audio Commenter 7</td>
</tr>
<tr>
<td>30</td>
<td>Chat Commenter 7</td>
</tr>
<tr>
<td>31</td>
<td>General Commenter (General conclusion of the forum)</td>
</tr>
</tbody>
</table>
Evaluation of the M-Orchestrate app for Scaffolding Pupils’ Collaborative Science Inquiry during COVID-19

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Abstract: This article reports on an evaluation study of enhancing pupils’ science learning with the collaborative inquiry-based learning model, namely, WeEngage, WeCollect, WeAnalyse, WeExplain and WeReflect as a scaffold embedded in the m-Orchestrate app for students to conduct their online collaborative science inquiry. An evaluation study was conducted to understand students’ perceptions on using the m-Orchestrate app for collaborative science inquiry during COVID-19.

Keywords: Collaborative inquiry-based learning, science learning, m-Orchestrate app

1. Introduction

Inquiry-based learning supported by Information and Communications Technology (ICT) tools, especially mobile devices, has been a desirable innovative approach to instructional practices in science education (Bell et al., 2010; Linn & Eylon, 2011). However, ICT-rich classrooms are complex, highly variable and unpredictable with many constraints (Roschelle, Dimitriadis, & Hoppe, 2013). Research evidence indicates that students lack collaborative inquiry-based learning skills in conducting the learning activities across formal and informal settings (e.g., Lakkala, Lallimo, &Hakkarainen, 2005; Sharples, 2013), especially during COVID-19 where all the lessons have to be conducted online. “How to scaffold students to conduct collaborative science in a mobile learning environment more effectively” remains an issue to be addressed. Thus, the focus of this research is to develop a mobile learning app termed “m-Orchestrate” (“m” stands for mobile, and “orchestrate” means management) that provides a practical solution to this question.

2. Design principles of the m-Orchestrate app

The design of the m-Orchestrate learning app integrates mobile technology into science curriculum, assessment, collaboration and inquiry-based pedagogy grounded in social constructivist theories with a more generic pedagogical structure as scaffolds for learners’ inquiry (Hakkarainen, Lipponen, & Jarvela, 2002; Sharples, 2013; Vygotsky, 1978). The pedagogical structure is comprised of five elements: “engage, explore, analyze, explain and reflect” developed from the “inquiry-based learning model” in our earlier study (Song, 2014; Song, 2016), which is employed in the design of inquiry phases in the m-Orchestrate-based learning. The adoption of these inquiry phases servers as a scaffold for students to facilitate their collaborative knowledge construction. The specific features of the m-Orchestrate app was presented in the next section.
3. Features of M-Orchestrate App

The m-Orchestrate app is a learning system that aims at supporting teacher orchestration and student collaborative science inquiry in a mobile learning environment (Song, Cao, Tam, & Looi, 2019). The design of this app adopts the collaborative science inquiry model, which is one of the collaborative inquiry-based models underpinned by social constructivist theories. The collaborative science inquiry model consists of five phases and adds “we” as a prefix before them to stand for collaboration, namely, WeEngage, WeCollect, WeAnalyse, WeExplain and WeReflect.

Figure 1 presents (1) technologies used to develop the app and (2) functionalities to support teaching and learning in collaborative science inquiry. The front-end interface of this app is powered by Unity, which is a visualizing development engine compatible with both iOS and Android mobile devices. Laravel, JavaScript and AJAX provide synchronous web services and API communication to support real-time interactions.

On the m-Orchestrate app, teachers can view, monitor and manage the inquiry status of each group. Then, resources and feedback are available to be assigned if needed. Such interventions can be addressed to corresponding groups, inquiry phases and activities. Thus, teachers can orchestrate diverse learning trajectories precisely and “just in time”.

The app provides various functions for students to conduct inquiry-based learning activities collaboratively. Some functions are available in all phases (e.g., Mind Map and Chat Room) and some are specific for an inquiry phase (e.g., data analysis and KWL tables).

4. Collaborative Science Inquiry on M-Orchestrate App

4.1 Functionalities to Support Students’ Collaborative Science Inquiry

Five collaborative inquiry-based phases, namely, WeEngage, WeCollect, WeAnalyse, WeExplain and WeReflect are embedded in the m-Orchestrate app (refer to Figure 1). The functions of each phase are presented below:

- In WeEngage, the teacher provides resources to activate students’ prior knowledge and students work in groups to raise their inquiry questions;
- In WeCollect, group members plan how to solve the inquiry questions, and divide the tasks to each member, then collect data in text, picture, spreadsheet or video format;
• In WeAnalyse, group members choose collected data in text, picture, spreadsheet or video format from WeCollect phase for analysis;
• In WeExplain, group members make a slideshow to present their whole inquiry process. The slides can be selected from the logged data in each inquiry phase, including the analysed data results, or uploaded pictures beyond the app;
• and in WeReflect, students reflect on what they know and what they want to know about the inquiry topic and what they have learned in the collaborative inquiry process.

The five inquiry phases are not linear. Students can work back and forth among these phases whenever they want. All these features are summarized in Table 1. In each inquiry phase, the features of location-based multimedia notes, collaborative Mind Map and Chat Room are provided. The location-based multimedia notes can help students record their inquiry findings and experiences in text, audio, image and video formats. The collaborative Mind Map allows students to work online simultaneously. The Chat Room enables students to communicate across class, group and individual levels. The student dashboard can help users identify the name, members, and completion rate of groups and the latest updates in the inquiry project.

<table>
<thead>
<tr>
<th>Inquiry Phase</th>
<th>Function</th>
<th>Functionality for student inquiry</th>
</tr>
</thead>
<tbody>
<tr>
<td>All phases</td>
<td>Notes</td>
<td>For making location-based notes with texts/audios/images/videos</td>
</tr>
<tr>
<td></td>
<td>Mind maps</td>
<td>For structuring information and synthesizing ideas collaboratively</td>
</tr>
<tr>
<td>WeEngage</td>
<td>Inquiry questions</td>
<td>For raising inquiry questions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For commenting on the raised questions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For deciding the question(s) to explore</td>
</tr>
<tr>
<td>WeCollect</td>
<td>Tasks</td>
<td>For planning inquiry tasks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For division of labour</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For collecting text/image/video/spreadsheet data</td>
</tr>
<tr>
<td>WeAnalyse</td>
<td>Data analysis</td>
<td>For analysing collected text/image/video/spreadsheet data</td>
</tr>
<tr>
<td>WeExplain</td>
<td>PPT slides</td>
<td>For presenting and elaborating findings</td>
</tr>
<tr>
<td>WeReflect</td>
<td>KWL tables</td>
<td>For reflecting on different topics</td>
</tr>
</tbody>
</table>

4.2 The Use of M-Orchestrate App During the Outbreak of COVID-19

Due to the outbreak of COVID-19, Hong Kong primary schools conducted most teaching and learning activities online. One class of students from a Hong Kong primary school were invited to adopt the m-Orchestrate app in their science learning to conduct collaborative inquiry learning activities. The inquiry topic of “prevention of diseases during the coronavirus pandemic” was reported in this paper as an example (see Figure 5).
A sample of 21 students were involved in this study and were divided into six groups (Group A, B, C, D, E and F). The learning process of Group D was randomly chosen to illustrate how collaborative science inquiry occurs on the m-Orchestrate app in detail. The inquiry process is presented in Figure 3.

In the WeEngage phase, students raised their inquiry questions. Based on the discussion and teacher’s suggestions, they decided to explore “What types of masks can help us prevent the coronavirus?” and “what are the major causes of common diseases?” (see Figure 3).

Then, they moved into the WeCollect phase to plan tasks, divide work labour division, collect data and information on the Internet (see Figure 4).
In the WeAnalyse phase, the students used spreadsheet and auto-generated diagram function to analyse data. Figure 5 shows that students in the Group D analysed the differences in lifetime and effectiveness between different types of masks (e.g., N95, medical mask, and cotton mask).

In the WeExplain phase, they demonstrated the cause of coronavirus and some common types of masks in the slideshow to elaborate on their findings (see Figure 6).
In the WeReflect phase, they made reflections on what they know (K), what they want to know (W), and what they have learned (L) before and after the inquiry process continuously (see Figure 7).

5. Data Collection and Analysis

A sample of 21 students were involved in collaborative science inquiry during the outbreak of COVID-19 to evaluate the m-Orchestrate app. Data collection included a questionnaire and two focus group discussions. The questionnaire was developed to assess the students’ perceptions of learning dashboard on the m-Orchestrate app. The English version questionnaire was adapted from the technology acceptance model (TAM) (Venkatesh & Davis, 2000) with 24 items in eight dimensions: perceived ease of use, perceived usefulness, attitude toward using the dashboard, social influence, facilitating conditions, self-efficacy, anxiety and behavioural intention. Responses were given on a five-point Likert-type scale, ranging from 1 for “strongly disagree” to 5 for “strongly agree”. It is noted that the number of participants reported in the survey was 20 due to one invalid response.

The interview questions were constructed based on the eight dimensions of the survey with follow-up questions, aiming at understanding students’ perceptions of the m-Orchestrate app for their collaborative science inquiry. A number of 17 participants were randomly chosen to be invited to the interview. Two interviews were recorded. Each of the interviews lasted about one hour.

In this study, both quantitative and qualitative data were collected for analysis. Student learning logs were used to explain the features of the dashboard on the app. Descriptive statistics were utilized...
to describe and compare the means with the assistance of SPSS version 26. Content analysis was used to analyse focus group interviews to triangulate the data about student perceptions of the app.

6. Results

6.1 Survey Results

The survey results are presented in Table 13. In this study, the Cronbach’s alpha was 0.917, suggesting that the items have relatively high internal consistency (Cronbach, 1951). Overall, the results of the quantitative data analysis show that the students held neutral attitude towards the m-Orchestrate app with an average mean of 3.47 (refer to Table 2).

Table 13. Descriptive Statistics of Students’ Perceptions of m-Orchestrate App

<table>
<thead>
<tr>
<th>Items</th>
<th>N</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived usefulness</td>
<td>20</td>
<td>1.67</td>
<td>5.00</td>
<td>3.58</td>
<td>.81</td>
</tr>
<tr>
<td>Perceived ease of use</td>
<td>20</td>
<td>1.33</td>
<td>4.67</td>
<td>3.43</td>
<td>.84</td>
</tr>
<tr>
<td>Attitude</td>
<td>20</td>
<td>1.75</td>
<td>5.00</td>
<td>3.65</td>
<td>.73</td>
</tr>
<tr>
<td>Social influence</td>
<td>20</td>
<td>2.00</td>
<td>5.00</td>
<td>3.55</td>
<td>.76</td>
</tr>
<tr>
<td>Facilitating conditions</td>
<td>20</td>
<td>2.33</td>
<td>4.67</td>
<td>3.67</td>
<td>.64</td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>20</td>
<td>2.67</td>
<td>4.67</td>
<td>3.72</td>
<td>.58</td>
</tr>
<tr>
<td>Anxiety</td>
<td>20</td>
<td>1.67</td>
<td>3.67</td>
<td>2.70</td>
<td>.56</td>
</tr>
<tr>
<td>Behavioural intention</td>
<td>20</td>
<td>1.67</td>
<td>4.67</td>
<td>3.45</td>
<td>.85</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

To be specific, the average means for the eight items were as follows: perceived usefulness (M=3.58, SD=.81), perceived ease of use (M=3.43, SD=.84), attitude toward using the app (M=3.65, SD=.73), social influence (M=3.55, SD=.76), facilitating conditions (M=3.67, SD=.64), self-efficacy (M=3.72, SD=.58), anxiety (M=2.70, SD=.56), and behavioural intention (M=3.45, SD=.85).

6.2 Interview Results

In the two semi-structured focused interviews, 17 participants were randomly chosen to be invited. Each of the interviews lasted about one hour. In general, students held a positive orientation towards using the m-Orchestrate app to improve collaborative science inquiry.

In the focused interview, they listed several advantages and provided useful suggestions. The following interview results were constructed in terms of eight dimensions: perceived usefulness, perceived ease of use, attitude toward the app, anxiety, facilitating conditions, social influence, self-efficacy and behavioural intention.

As for the perceived usefulness of the m-Orchestrate app, all students believed five stages (WeEngage, WeCollect, WeAnalyse, WeExplain and WeReflect) embedded on the app is useful for collaborative science inquiry. Additionally, interviewees (pseudonyms were used) explained:

- **This app was very interactive. I was very clear about the division of labour in my group. When I encountered difficulties, I just left a message as a comment, my groupmates or teachers would reply to me. (Nick)**
- **In the WeCollect phase, we could divide labours and check each group member’s responsibility. I think it was essential to teamwork. In addition, we could add videos, upload pictures, and record our voice to contribute the same inquiry task. It felt like a real collaboration moment! (Julie)**

Regarding the perceived ease of use, nine students held positive attitudes, while five students held neutral attitudes and one student reported it was not easy for him to use. They commented on “Mind map” and “analysing pictures and spreadsheets”. Students said the Mind Map was useful in brainstorming, but it was not easy to add links between blocks. In addition, functions of analysing pictures and spreadsheets in the WeAnalyse phase were complicated which need more explicit guidance.
for students to use. About the interview question on students’ anxiety when using the app, four students said they were anxious when they failed to upload videos and pictures because there was no message to tell them whether they upload successfully or not.

For the question of “how should the m-Orchestrate app be improved such that you will use it more frequently to support your learning?” In addition, Jack appreciated the function of Chat Room which supported students’ synchronous communication on the app. However, he suggested that real-time notifications could be used to remind students, otherwise he would miss new messages from peers. In addition, Nick reported, “I noticed that there were three modes in the WeCollect phase: pending, in-progress and completed, and I felt frustrated to mark the completion status after completing every task.” He suggested that these manual operations could be simplified.

As for the attitude towards the m-Orchestrate app in science inquiry, all students showed positive attitudes. They stated that it was fascinating that they could use the app to guide and support collaborative science inquiry. Students said they often got stuck on what they should do in an inquiry project. But the app helped divide the inquiry process into five phases, namely, WeEngage, WeCollect, WeAnalyse, WeExplain, and WeReflect step by step. The whole learning process was quite clear and logical, and it was easy to follow. However, 88.2% of students considered it would be better if a built-in guidance or demonstration video could be provided to grasp what the app can help them at a glance.

As for social influence, all students agreed that they would get motivated and adjust learning pace after checking group members’ learning process on the m-Orchestrate app. Alice and Nick acknowledged that they could instantly see everyone’s contribution on the project from the dashboard. Julie and Sandy stated that they could adjust their learning paces according to others’ progress:

- If other members have done their tasks but one team member was still working, we could ask him/her if he/she needs help. Teachers could also see the students who have not completed the task and give advice. (Julie)
- We could adjust the labour division to improve the whole group’s efficiency if we found someone finished the required tasks very quickly. (Sandy)

About the question on self-efficacy – Do you think you can use the m-Orchestrate app yourself for your inquiry learning without other’s technical support? Most of the students (88.2%) thought it was not easy to use if there was no one around to tell them what to do. Therefore, guidance is necessary for the later implementation of the m-Orchestrate app to support primary students’ collaborative science inquiry.

In terms of behavioural intention, all students stated that they understood the importance and meaning of team collaboration and acknowledged that the m-Orchestrate app could guide and motivate them to contribute more to the group project.

7. Conclusion and Future Work

This article reports on an evaluation study of enhancing pupils’ science learning with the collaborative inquiry-based learning model, namely, WeEngage, WeCollect, WeAnalyse, WeExplain and WeReflect as a scaffold embedded in the m-Orchestrate app for students to conduct their online collaborative science inquiry. An evaluation study was conducted to understand students’ perceptions on using the m-Orchestrate app for collaborative science inquiry during COVID-19. The results show that their perceptions were generally positive, and they reported that the app was useful for their collaborative learning. Students also provided useful suggestions for improving the app.

Future work focuses on refining the app and scaling up its implementation. Regarding of the feedback by participants, several critical bugs were identified (e.g., fail to upload videos and pictures and link between blocks in mind maps) and will be fixed up. A demonstration video will be made to instruct primary students at the beginning of using the app. For better experience of conducting collaborative science inquiry on the m-Orchestrate app during the outbreak of COVID-19, the functions to support remote collaboration will be considered, such as update notification and marking different users on their changes to the learning content.
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Using Robot-based Inquiry Learning Activities for Promoting Students’ Computational Thinking and Engagement

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Abstract: Nowadays, an important robot in education as a strategy is the meaningful integration of technology to encourage students to think and connect to a real-world situation. Moreover, robots offer an excellent tool for teaching and learning STEM disciplines that can be employed in a variety of subjects. Many studies focused on promoting students’ conceptual knowledge. However, essential skills are crucial for the future success of students in the 21st century that is computational thinking refers conceptual foundation required to solve problems effectively. The purpose of this article is to describe the robot-based learning activity that utilizes robotics to enhance students’ computational thinking. Our study has been designing based on a revised 5E learning model (engagement, exploration, explanation, execution, and evaluation). The evaluation study was conducted with 29 high school students in robot activities. The authors found that the framework not only positive supports the three dimensions of computational thinking in terms of concept, practice, and perspective, but also enhances the students’ engagements toward robot activities.

Keywords: Essential skill, engineering education, educational robot

1. Introduction

Nowadays, an important educational robot as a strategy is the meaningful integration of robots into learning to encourage students to think and connect to a real-world situation. In the past decade, the use of robots for education has gained a lot of attention from researchers and educators. Many experiments used the mBot Robot kit, it is easy-to-use for students to get hands-on experience with graphical programming (Hutamarn et al., 2017; Zhong & Wang, 2019). In addition, a low-cost robot platform has been used to support student learning to develop hands-on open-source robots that is both inexpensive and reliable (Darrah, Hutchins, & Biswas, 2018; Tribelhorn & Dodds, 2007). Educational robots help students develop essential skills in the classroom that significant in connecting the concept to real life. Computational thinking (CT), which is one of the essential skills for students in the 21st century. CT is often regarded to be the basic skill of computer science is related to science, engineering, and mathematics disciplines. Additionally, an educational robot should be based on sound teaching and learning strategy (Özgür et al., 2017). Thus, the 5E learning cycle model-oriented learning cycle approach is a realistic, constructivist method of learning which employs students through a well-designed learning process (Dorji, et al., 2015; Piyayodilokchai et al., 2013). It remains a challenge to trigger students’ constructing essential skills (Shute, Sun, & Asbell-Clarke, 2017); thus, it is crucial to afford students learning activities for constructing computational thinking. That is, the focus is on transforming teaching and learning strategy into a robotic context and on how the robot can be used pedagogically to promote students’ essential skills.
Therefore, the main purpose of this study was the harmonization of an educational robot and learning pedagogy. Thus, this study investigates students’ computational thinking and engagement resulting from learning activity following research questions:

1. Do students who participate in robot-based learning activities have computational thinking?
2. What are the students’ engagements of the robot-based learning activities?

2. Literature Review

2.1 Robot-based Activities

Robotics is a branch of engineering that includes many subject matters that combine with science, technology, engineering, and mathematics or STEM disciplines. A robot is a machine used in variety of different tasks. A recent study has found that using a robot in education is increasingly being defined as a significant instrument of teaching and learning that integrated STEM education is crucial for the future success of students in the 21st century (Kelley & Knowles, 2016; Larkin, 2017). This makes the learning to be able to connect and relevant to the students’ experience, together with the complexity of the global situation. So, it can be suggested that how to use a robot for enhancing computational thinking skills. With the abilities to attract and encourage the students’ learning process engagement of the robot, it is resulting in hands-on and self-directed learning by touching and manipulating the robot directly (Cheng, et al., 2017; Ziaeeefard, Miller, Rastgaar, & Mahmoudian, 2017). Many studies proposed the benefit of an educational robot able to motivate students’ learning with authentic learning activities based on real-world problems (Julià & Antoli, 2019) and to improve the students’ confidence and skills related to abstract nature and advanced mathematics needed to understand the topic (Wu, de Vries, & Dunsworth, 2018). Using a robot in education not only employ inside and outside the classroom but also employ in meaningful learning activities for student as well. Some study proposed the robot workshop for high-school students have the opportunity to engage three-day workshop for who interesting science and technology are becoming the engineering students (Chookaew et al., 2018).

2.2 Learning approach

The importance to adapt the learning cycle approach to drive learning activity is widely recognized. The learning cycle approach is an educational strategy or technique that encourages students to discover or construct information by themselves, instead of having teachers directly provide the information through a scientific process (Duran & Duran, 2004; Pedaste et al., 2015). Learning cycle processes are able to improve students’ achievement relative to scientific practices and increasing students’ conceptual knowledge (Marshall, et al., 2017). The 5E instructional learning cycle is contemporary 5 learning-phases consisting of engagement, exploration, explanation, elaboration, and evaluation that are the most effective way of engaging students (Bybee, 2014). In the engagement phase, the students are asked to make connections between past and present learning experiences and organize their thinking toward the learning. The exploration phase is used to encourage students to explore questions and possibilities, and design and conduct a preliminary investigation followed by the explanation phase. The students are asked to explain their understanding of the concept. In the elaboration phase, the students are provided an opportunity to apply their understanding of the concept by conducting additional activities. Additionally, they evaluate themselves about the learning progress whether they have achieved the educational objectives.

2.3 Computational Thinking

The computational thinking basis concept of mathematics educations research (Papert, 1996). After that, computational thinking was described by many researchers in many times and worldwide. In the last twenty years, computational thinking becomes to a fundamental skill for everyone in every field, not just for computer scientists, especially for students in 21st-century skills that should have analytical
ability and reading, writing, and arithmetic process systematically (Wing, 2006, 2008). According to the finding of many studies confirmed that computational thinking is the conceptual foundation required to solve problems effectively (Shute et al., 2017). Based on the core concepts of computational thinking proposed by Wing, 2008 include decomposition, pattern recognition, abstractions, and algorithm design. In addition, computational thinking components are classified into three dimensions include computational concepts (the concepts that students employ), computational practices, (problem-solving practices that occur), and computational perspectives (the students’ understandings of themselves) (Brennan & Resnick, 2012).

In this study, learning strategy is an empirically learning process for driving the robot activity consisting of engagement, exploration, explanation, execution, and evaluation. According to measuring students’ computational thinking is a complicated but necessary task for understanding the effectiveness of robot activities. Our investigation focused on the implications of claims about students’ computational thinking three dimensions consisting of Computational thinking concepts: the concepts that students employ to learn and understand during activities, Computational thinking practices: problem-solving practices that occur in the learning process, and Computational thinking perspectives: students’ understandings of themselves, the relationships between team members.

## 3. Methodology

### 3.1 5E Robot-based Activities

Usually, commercial educational robot kits are used as learning tools in learning activates during the curriculums in the classroom or during learning activity in workshops, nevertheless, teachers frequently need to adapt the robot kits for specific learning objectives. Besides, commercially available robot kits are often expensive and are not easy to modify for learning activities. In this study, we developed robot kits called MEC-Ed (Mechatronic Education robot) that are low-cost robots prototype. The robots have been designed that can be built in many different forms. Each part of the robot was printed with a 3-dimensional printer or 3D printer. Also, the MEC-Ed robot is consist of many sensors to detect the task in scenarios, those sensors are ultrasonic (used measures the distance to an object with ultrasonic sound waves), line follower (used follow white or black lines), IR flame (used detect the presence of fire or other infrared sources), and RGB color sensor (used for detecting primary colors namely red, green and blue). The MEC-Ed robot kit can be controlled by the Scratch programming environment. The program is a drag-and-drop block for writing commands of the robot to operate with the mBlock program which is a freeware program that can be used to control the Arduino board. The MEC-Ed robots are introduced as learning material to employ engineering design as a motivator to teach STEM education.

In this work, the authors have revised the original 5E of phase 3 to make it to be more appropriate with robot activities named “Execution” instead of “Elaboration”

- **Engagement phase:** The instructor encourages the students’ experience with the real world. Asking a question, defining a problem or task in order to motivate students to engage the learning activity. They are able to take what they have learned from the scenario with the mission activities.

- **Exploration phase:** The students explore and plan an idea to solve the problem or mission. They are able to think about what they have discovered from the scenario.

- **Explanation phase:** This phase provides the students with the common use of terms relative to the missions. The students explain the solution to solve a problem using common scientific terms. The student presents the methods about the control robot and justifies the approach to solving the problem in order to carry out the mission.

- **Execution phase:** The students execute the robot mission with a challenge. They are able to operate the solution through the activities to mission success. At this moment, the student employs systematic thinking with different problems upon their robot’s settings and programming.
3.2 Participants

The participants were 29 high school students (18 males and 11 females) who are willing to participate in our research. The students ranged from 16 to 18 years of age.

3.3 Experiment design

The participants were divided into groups (3-4 participants per group) were formed to undertake with ask the students to form a line. They should line up alphabetically by given name then count off in groups 1, 2, 3 then and continue until all groups are formed. Every group has a mentor during activities for advising and facilitating the learning process in this activity. The robot learning activity was completed in three days (7 hours per day total of 21 hours). In research method the students followed the five stages of robot activity process are detailed as follows:

- **Stage 1 (Engagement):** Begins the first step addresses motivation to student-related components and functions of the robot and basic programming to control a robot. The students were introduced to the concepts of robot activities including assemble a robot, program robot movement, and learning the sensors.
- **Stage 2 (Exploration):** This step addresses the mission for solving a problem. The students have perceived the situation and engage the activity with the team to explore the problems. After that, they identified the problem and asking the questions with the robot missions.
- **Stage 3 (Explanation):** When the students know the problem based on their missions. They explained the solution to solve problems and plan or design activity in the next section.
- **Stage 4 (Execution):** In this step, the students attempted to execute the robot mission and the robot competition. They have hand-on activities for the competition.
- **Stage 5 (Evaluation):** In the last, the students’ mission outcomes were evaluated. In addition, the students were assessed computational thinking during joint learning activity.

**Figure 1. Robot-based activities framework**

As shown in Figure 1, the elements of robot-based activities framework for learning in STEM (Science, Technology, Engineering, and Mathematics) were strategically embedded in learning activities with 5E instructional learning model to support students’ computational thinking and engagement.
4. Results

4.1 The results in terms of the students’ computational thinking

The items in this observation checklist were developed to the three dimensions of computational thinking that cover all concepts of the robot activities including 14 items: computational concept (4 items), computational practices (5 items), and computational perspectives (4 items). This checklist, the mentors have given the students rated each item on a five-point Likert scale (1 = Failed, 2 = Passed, 3 = Acceptable, 4 = Good, 5 = Excellent). This scale established expert validity through evaluated by five professors of educational robotics with more than 7 years of experience. The internal consistency for the overall scale was 0.82.

Table 1. Means and SDs of the students’ Computational thinking

<table>
<thead>
<tr>
<th>Dimension items</th>
<th>Mean</th>
<th>S.D.</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Computational Concept (CC)</strong></td>
<td>4.24</td>
<td>0.66</td>
<td>Good</td>
</tr>
<tr>
<td>1. Explaining the function of sensors</td>
<td>4.10</td>
<td>0.66</td>
<td>Good</td>
</tr>
<tr>
<td>2. Modifying the robot follows the mission with scientific and mathematical concepts</td>
<td>4.28</td>
<td>0.69</td>
<td>Good</td>
</tr>
<tr>
<td>3. Programming the robot motion for the missions.</td>
<td>4.38</td>
<td>0.61</td>
<td>Good</td>
</tr>
<tr>
<td>4. Identifying the barriers that influence to the missions.</td>
<td>4.21</td>
<td>0.66</td>
<td>Good</td>
</tr>
<tr>
<td><strong>Computational Practices (CP)</strong></td>
<td>4.14</td>
<td>0.78</td>
<td>Good</td>
</tr>
<tr>
<td>5. Planning the systematic problem-solving</td>
<td>4.03</td>
<td>0.61</td>
<td>Good</td>
</tr>
<tr>
<td>6. Applying the sensors to complete the missions.</td>
<td>4.48</td>
<td>0.81</td>
<td>Good</td>
</tr>
<tr>
<td>7. Controlling the robot to complete the missions.</td>
<td>4.28</td>
<td>0.78</td>
<td>Good</td>
</tr>
<tr>
<td>8. Solving the problems related to the robot motion.</td>
<td>4.38</td>
<td>0.72</td>
<td>Good</td>
</tr>
<tr>
<td>9. Operating the missions with confidence and accuracy</td>
<td>3.72</td>
<td>0.69</td>
<td>Acceptable</td>
</tr>
<tr>
<td>10. Performing an independent work with confidence</td>
<td>3.93</td>
<td>0.74</td>
<td>Acceptable</td>
</tr>
<tr>
<td><strong>Computational Perspectives (CPP)</strong></td>
<td>4.09</td>
<td>0.60</td>
<td>Good</td>
</tr>
<tr>
<td>11. Explaining the benefit of robot activity.</td>
<td>4.14</td>
<td>0.57</td>
<td>Good</td>
</tr>
<tr>
<td>12. Connecting between the mission and the real-life situation</td>
<td>4.34</td>
<td>0.48</td>
<td>Good</td>
</tr>
<tr>
<td>13. Applying scientific knowledge to solve the problem</td>
<td>4.03</td>
<td>0.72</td>
<td>Good</td>
</tr>
<tr>
<td>14. Adapting the activity into the real-life situation</td>
<td>3.86</td>
<td>0.51</td>
<td>Acceptable</td>
</tr>
</tbody>
</table>

As shown in Table 1, the students’ computational concept were at good level (M= 4.24, S.D. = 0.66), practices and perspectives M= 4.14 (S.D. = 0.78), and M= 4.09 (S.D. = 0.60), respectively.
4.2 The results in terms of students’ engagements

The items in this engagement questionnaire were adopted a revised version (Hutamarn et al., 2017) three dimensions of students’ engagements after attending the robot learning activity that consisted of 11 items to assess behavioral engagement (3 items), cognitive engagement (4 items), and emotional engagement (4 items), while the latter examines students’ satisfaction on 5-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = agree, 5 = Strongly Agree) The internal consistency for the overall scale was 0.79.

Table 2. Means and SDs of the students’ engagement toward robot inquiry-based learning activates

<table>
<thead>
<tr>
<th>Questionnaire items</th>
<th>Mean</th>
<th>S.D.</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavioral Engagement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q1. I can participate and work in a group activity.</td>
<td>4.62</td>
<td>0.49</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td>Q2. I attempt to define and discuss the missions.</td>
<td>4.48</td>
<td>0.56</td>
<td>Agree</td>
</tr>
<tr>
<td>Q3. I think an environment not a barrier to my learning.</td>
<td>4.48</td>
<td>0.56</td>
<td>Agree</td>
</tr>
<tr>
<td>Cognitive Engagement</td>
<td>4.40</td>
<td>0.61</td>
<td>Agree</td>
</tr>
<tr>
<td>Q4. I think robot activity improves my thinking process and work.</td>
<td>4.52</td>
<td>0.50</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td>Q5. When I am not sure something, I always consult a mentor.</td>
<td>4.69</td>
<td>0.53</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td>Q6. When the problem occurs, I attempt to find the solution myself.</td>
<td>4.10</td>
<td>0.66</td>
<td>Agree</td>
</tr>
<tr>
<td>Q7. I always plan before I operate in an activity.</td>
<td>4.28</td>
<td>0.52</td>
<td>Agree</td>
</tr>
<tr>
<td>Emotional Engagement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q8. I think I can apply the robot activity in my life.</td>
<td>4.38</td>
<td>0.61</td>
<td>Agree</td>
</tr>
<tr>
<td>Q9. I feel that robot activity is a challenge for me.</td>
<td>4.52</td>
<td>0.62</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td>Q10. I prefer robot activity.</td>
<td>4.69</td>
<td>0.46</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td>Q11. I think robot activity not only makes me have knowledge but also have fun as well.</td>
<td>4.66</td>
<td>0.48</td>
<td>Strongly Agree</td>
</tr>
</tbody>
</table>

As shown in Table 2, in the students’ behavioral engagement dimension the students were strongly agree (M= 4.24, S.D. = 0.66) while the students’ emotional engagement dimension were agree (M= 4.40, S.D. = 0.61), and the students’ cognitive engagement dimension were agree (M= 4.49, S.D. = 0.58), respectively.

5. Conclusions

In this article, the authors attempt to propose the robot inquiry-based learning activates to foster students’ computational thinking. For the development of educational, the robot called MEC-Ed robot kits that can support students’ computational thinking through a learning approach to drive activity with missions. The results demonstrate that the students’ three dimensions (behavioral, cognitive, and emotional engagement) of engagement are at a high level.

The educational robot activity is particularly effective in delivering the contents of difficult disciplines for learning, it can re-establish a balance between the student and the technological material because the student can learn and develop computational thinking skills as well. This can significantly boost the learning environment more completely; in the meantime, they can naturally understand the learning phenomena both positive and negative in order to improve later. Research finding, it has a generalization issue due to the implementation of one sample group. In the
future, a comparison study between groups of samples, experiments, or interventions can enhance the impact of this finding.

The advantages of the educational robot that integrate with the learning approach to enhanced student thinking are presented here. In particular, in the future work, we should attempt to implement this MEC-ED robot in a real case study and then extend it to different realities because the student experience, the provincial and regional norms make a difference in the outcomes.

Acknowledgements

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References


Implementation of Multimedia-based Inquiry Learning to Promote Students’ Understanding of Automated Factory Systems and Their Perceptions

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Abstract: With the introduction of the smart factory, automation systems have changed the factors and elements associated with traditional manufacturing systems. Smart factories incorporate the current features of smart systems so that they can compete in the future. It is important to determine industrial requirements, and provide students in higher education engineering programs with the necessary training. However, it is frequently the case that conventional automated factory learning focuses on lectures about automation systems without incorporating interesting learning materials. In addition, many students have trouble understanding the concepts and the new technologies associated with automation systems. In this study, we attempt to increase the students’ understanding of the relevant subject content with the use of multimedia-based inquiry learning. This findings of this research study indicate that students gain better conceptual knowledge and understanding after participating in multimedia learning. Such an approach offers a medium gain in the progression of their understanding and also provides evidence of a positive increase in student perception.

Keywords: inquiry-based learning, mobile learning, engineering education

1. Introduction

Thailand is an emerging economy that is driven by its manufacturing sector. However, recent data has shown that not everything is going well. In response to this, the Thai government has attempted to promote engineering education to support Thai industry. The most important aspect of this has been how to change the engineering education learning process in such a way as to encourage industrial learning and training for the future. The so-called Fourth Industrial Revolution (Industry 4.0) is a collective term for technologies that will enable the manifestation of smart industry. The smart factory is part of Industry 4.0 that has rapidly grown and has become increasingly important, especially in the case of those companies pertaining to the engineering field (Prinz et al., 2002; Büchi et al., 2020) that incorporate five key components: Big Data, Cloud System, Internet of Things (IoT), Cyber-Physical Systems (CPS), and Smart Factory. Together, these make up the heart of Industry 4.0 (Mabkhot et al., 2018). The smart factory introduces the automated system changes to the factors and elements that make up traditional manufacturing systems, and incorporates the current requirements of smart systems so that it can compete in the future. It is important to look into the requirements of industry and impart the relevant training to students.

However, conventional automated factory learning often involves lectures about automation systems without incorporating any interesting learning materials. Consequently, many students have trouble understanding the relevant concepts and the new technologies relating to automation systems.
Automated factory systems require learning about two concepts in the form of servo motors controlled with the aid of the IoT, and integrating programmable logic controllers (PLCs) with SQL database topics. Both these aspects must be considered in order to prepare students for careers in smart factories. The students should understand the connection between machines and the automation process. However, many students lack the necessary comprehension and skills. In this study, we attempt to increase the students’ understanding of the subject content with the use of multimedia-based inquiry learning. In this research we describe a method associated with teaching about an automated factory system that increases students’ understanding. The study investigates the situation by asking the following research questions:

1. Do students who participate in multimedia-based inquiry learning have an understanding of the concepts associated with automated factory systems?
2. What are the students’ perceptions of multimedia-based inquiry learning?

2. Related Study

2.1 STEM education in engineering curriculum

During this time of change, educational engineering has attempted to integrate features of the STEM (science, technology, engineering, and mathematics) discipline with engineering curriculum units in such a way that students are aware of the importance of understanding these disciplines in order to prepare themselves for the high technological present and future (Mathis et al., 2017; Fan & Yu, 2017; Siverling et al., 2019; Kajonmanee et al., 2020).

Yakimov & Iovev (2019) point out the main objectives with regard to the development of a learning environment for encouraging practice in the field of mechatronics and industrial automation. The use of real industrial devices provides an education in conditions close to reality. It is expected that this will lead to a successful education in the STEM field which will allow students to acquire sustainable theoretical knowledge and practical skills for the start of their career in factory automation.

However, some of the problems associated with such an acquisition is deciding how to apply the technology in such a way as to enhance learning when it comes to incorporating students’ hands-on activities in engineering education. In this study, we focus on two student learning outcomes: 1) the extent to which students are able to understand how the servo motor process is controlled, and 2) the extent to which students are able to understand the integration of PLCs with SQL databases as part of the industrial automation system.

2.2 An automation factory system learning

Curriculum content related to automated factory systems is important for mechatronics, mechanical, and electrical engineering students. This content focuses on how factory equipment is connected in order to improve the efficiency and reliability of process control systems. Therefore, two important aspects for constructing multimedia learning approaches are as follows:

- Servo motor systems controlled with the use of the IoT: This content is related to a servo motor that is a rotary actuator. This allows for the precise control of speed, torque, acceleration, and angular and linear position. It uses several applications such as that every joint on the robot is connected by a servomotor in order to give the robot arm a precise angle, or using servo motors as part of the manufacturing process in order to start, move, and stop conveyor belts carrying products to various stages.
- Integrating PLCs with SQL databases: This content is related to using programmable logic controllers (PLCs) connected with a database such as the assembly line in the smart factory needing an easy and fast way to log or obtain data online about the production equipment.
2.3 Multimedia-based inquiry learning

Many studies have attempted to include an inquiry-based learning (IBL) approach in a variety of courses to increase students’ conceptual understanding and increase their learning (Aboagye et al., 2018; Thongkoo et al., 2019). In addition, using multidisciplinary teaching which combines inquiry-based learning activities, the students are able to achieve real learning (Zhai, 2019).

Inquiry-based learning is a popular learning approach that is used to engage students in an authentic scientific discovery process, in order to develop their knowledge and play a positive role in training them in terms of innovation. It has obvious advantages in terms of the learning process, a process which includes 5 phases: Orientation phase: Stimulating curiosity about a topic and addressing a learning challenge through the provision of a problem statement; Conceptualization phase: Stating theory-based questions and/or hypotheses; Investigation phase: Planning exploration or experimentation, collecting and analyzing data based on the experimental design or through exploration; Conclusion phase: Drawing conclusions from the data and comparing inferences made based on the data with regard to hypotheses or research questions; and Discussion phase: Presenting the findings of particular phases or the whole inquiry cycle by communicating with others and/or controlling the whole learning process or its phases by engaging in reflective activities (Pedaste et al., 2020). Many studies have proposed the use of advancements in digital technologies for creating an effective tool in the form of an integrated inquiry-based approach through a technology-enhanced learning environment (Srisawasdi, 2018; Jaimeetham & Srisawasdi, 2018; Wongwatkit el al., 2017).

In this study, we propose the use of multimedia material or digital resources that are provided to support students’ learning via mobile learning. The principle underlying the design of learning activities incorporating multimedia material is that it has to use QR code on student handouts that have learning content based on the concept of a servo motor controlled with the use of IOT, and integrating PLCs with SQL databases. Subsequently, the inquiry-based learning process is used to drive learning activities associated with multimedia materials as shown in Figure 1.

![Figure 1. The structure of the multimedia-based inquiry learning](image)

3. Method

3.1 Participants

The participants in this study consisted of 15 vocational education and training students (12 male and 3 female) whose ages ranged from 18 to 22. All of the students have experience of using a mobile device in their daily lives.

3.2 Procedure

The experiment data were conducted over a 4 week period (1 week / 3 hours total of 120 hours). A one group pre- and post-test research design was used to study the students’ understanding. The learning materials for the topics, including handouts for the students, reading materials, and video presentations
on YouTube, were prepared before the learning activity started, so that when the activity started all materials were ready to support student learning.

In a learning activity, the students were oriented by introducing a learning topic. All students took the pre-test which included 40 items and lasted about 40 minutes. The teacher then employed a questioning technique for generating interest in real problems in an industrial setting. The students then used a handout to investigate and synthesize new knowledge in order to solve practical problems. After the activities, all students took the post-test (40 items in about 40 minutes). Then, as shown in Figure 2, they completed the questionnaire on their mobile devices with regard to their perceptions regarding inquiry-based learning using multimedia materials.

Figure 2. Illustrative examples of student learning

4. Results

4.1 The results in terms of student understanding

The data collected with regard to the students’ understanding are as shown in Table 1. The paired-samples t-test showed that there is a statistically-significant difference ($t = 21.46, p < .001$) between the students’ post-test scores and their pre-test scores on the test of conceptual understanding.

In addition, the normalized gain (Hake, 1998) was 0.62, indicating that the students achieved better conceptual knowledge and understanding after participating in the multimedia learning process and that the progression of their understanding indicated a medium gain.

Table 1. Pre- and post- conceptual understanding test

<table>
<thead>
<tr>
<th>Test</th>
<th>N</th>
<th>Mean (SD)</th>
<th>t</th>
<th>p</th>
<th>Normalized gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-test</td>
<td>15</td>
<td>16.33 (2.65)</td>
<td>21.46</td>
<td>0.00*</td>
<td>&lt;g&gt; =0.62</td>
</tr>
<tr>
<td>Post-test</td>
<td>15</td>
<td>31.07 (2.49)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.2 The results in terms of student perception

A questionnaire was administered to investigate the students’ perception of the multimedia learning process after participating in the learning activity. The questionnaire was adapted from Chookaew et al.’s (2015) attitude questionnaire, and employed a five-point Likert scale ranging from 1 ‘strongly disagree’ to 5 ‘strongly agree’. This questionnaire consisted of eight items divided into three categories: perceived satisfaction, perceived usefulness, and behavioral intentions.

Table 2. Means and SDs of the students’ perception
<table>
<thead>
<tr>
<th>Questionnaire items</th>
<th>Mean (SD)</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived satisfaction:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. I am satisfied with using the multimedia materials as a learning assisted tool</td>
<td>4.40 (0.71)</td>
<td>Agree</td>
</tr>
<tr>
<td>2. I am satisfied with the learning content</td>
<td>4.07 (0.68)</td>
<td>Agree</td>
</tr>
<tr>
<td>3. I am satisfied with the multimedia-based inquiry learning activities</td>
<td>4.60 (0.61)</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td>Perceived usefulness:</td>
<td>4.30 (0.53)</td>
<td>Agree</td>
</tr>
<tr>
<td>4. I believe the multimedia materials act as a useful learning tool</td>
<td>4.13 (0.50)</td>
<td>Agree</td>
</tr>
<tr>
<td>5. I believe the multimedia-based inquiry learning activities are useful</td>
<td>4.47 (0.62)</td>
<td>Agree</td>
</tr>
<tr>
<td>Behavioral intentions:</td>
<td>4.33 (0.63)</td>
<td>Agree</td>
</tr>
<tr>
<td>6. I intend to use the multimedia materials to assist my learning</td>
<td>4.53 (0.62)</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td>7. I intend to use the contents in the multimedia-based inquiry learning to assist my learning</td>
<td>4.40 (0.71)</td>
<td>Agree</td>
</tr>
<tr>
<td>8. I intend to use the multimedia-based inquiry learning activities as a supplementary learning tool</td>
<td>4.33 (0.71)</td>
<td>Agree</td>
</tr>
</tbody>
</table>

As shown in Table 2, the students’ perception with regard to the inquiry-based learning approach using multimedia materials was deemed to be satisfactory with Mean = 4.36 and SD = 0.70, in terms of perceived usefulness with Mean = 4.30 and SD = 0.53, and in terms of behavioral intentions with Mean = 4.33 and SD = 0.63. These indicate a positive level of student perception with regard to learning with the use of multimedia materials.

5. Discussion and Conclusion

The advantages of using multimedia technology as a means of driving learning activities that relate to engineering content are consistent with the theoretical framework with regard to assisting students’ understanding of automated factory systems as part of their engineering education.

This study examined the effectiveness of inquiry-based learning activities through the use of multimedia material in terms of supporting students’ understanding and encouraging a positive perception of the approach. The activity systematically embedded domain knowledge in relation to STEM (science, technology, engineering, and mathematics) areas, and was especially successfully in merging the engineering content as a result of the learning environment. This study can play an important role in encouraging further research within engineering education with regard to this topic.

This study provides valuable insights for engineering educators and identifies a way forward for future research. Further studies might explore how best to access improved learning performance and skills. In addition, the integration of hands-on activities as part of the learning process should be considered as a means of encouraging engineering students’ understanding and practice.

Acknowledgements

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A Hybrid Diagnostics-based Learning System for Promoting College Students’ Digital Security: A Challenge to Digital STEM in College

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Abstract: Numerous of traditional online system are not response to learner’s preference. Learners can have a lack of encouragement and a learning achievement rate is getting low. This research aims to develop an adaptive learning system using Hybrid Learning Diagnostic Approach (HLDA) in order to diagnose and detect learners’ learning styles according to the criteria in the Index of Learning Style (ILS) into 3 dimensions (1) active-reflective, (2) visual-verbal, and (3) sequential-global. A Learning EcoSystem (LES) was purposed and implemented as a web-based learning system consists of four main learning modules engaging with a story-based learning content regarding cyber threat. The experiment with students at Mae Fah Luang University show that the posttest results higher than the pretest, indicating that students from Learning Eco System had a significant improvement of learning outcome. Besides, this study also presents the challenges of STEM-based education in digital environment by integrating with many areas of learning disciplines.

Keywords: adaptive learning system, learning style, social learning analytics

1. Introduction

The fundamental purpose of an adaptive learning system (ALS) is to enhance the learning processes of its learners through personalization and adaptability of the learning content (Santos et al., 2003). In order to achieve this for each individual learner, formulating an adequate diagnosis is one of the essential procedures. Diagnosis in an adaptive learning system refers to the processes and methods used in identifying the nature of a learner’s learning style. During the past few decades, numerous research studies and application on the mechanism of learning indicate that different individuals are influenced by different styles and techniques of learning (Al-Dujaily, 2008). This is why obtaining a sturdily fine diagnostic process is very much crucial for 21st century learners. As an endeavor to provide systematic distinctions among different learning styles, various models for learning diagnosis have been constructed and published. Some of the most widely recognized learning style models used in learning diagnosis are Felder-Silverman (1988), Kolb’s learning styles (1984), Honey and Mumford model (1986) etc. Learning diagnosis plays an important role not only in providing more meaningful and personalized learning experiences but also in enlarging the learner’s motivation and attitude (Hwang et al., 2008).

Despite the rising acceptance and popularity of adaptive learning systems, the lack of consideration for utilization of learners’ data from outside resources still draws back their sophistication. In practice, the diagnostic models utilized in most ALSs mainly analyze learners based
on their actions and knowledge gathered throughout the course of learning (Santos et al., 2003). For instance, data regarding learners' current knowledge on a subject is collected only through questionnaires, quizzes, and other onsite interactions as a learning process. However, these are not as sufficient since external factors that most contribute to learners' motivation and attitude such as learners' preference and learning styles (Hung, Chang, & Lin, 2016; Graf & Kinshuk, 2007;) are being disregarded. Without regard to these learning attributes, diagnosing and building an adaptive model solely from learners' interactions with a given system becomes a potential problem when the data gathered don’t reflect the real intentions of the learners (Yoon et al., 2008). For example, when a learner interacts with a diagnostic system that is inconsistent with his interest, the data produced from such interaction become less meaningful for the diagnosis outcome (Yoon et al., 2008). Thus, minimizing these problems could help maximize the sophistication of adaptive learning systems for 21st century education.

Alongside the rise of social networking among the population in the present days, conducting the analysis on patterns and behaviors of users occurred on those social platforms has benefited many areas, including education. In fact, social learning analytics (SLA) is a term used to describe the utilization of activities and behaviors of learners conducted from such platforms to learning environments (Shum & Ferguson, 2012). The data accumulated from these sources can reveal a great deal about learners, ranging from simple profile data to social interaction and preferences. Utilizing these prime data to learning diagnosis opens up more possibilities to help identify a more precise learning trait and characteristic about a learner (Baker & Inventado, 2014; Siemens & Baker, 2012). With the incorporation of SLA as part of the diagnosis process, the outcome for learning style and preferences of a learner could genuinely reflect those that naturally occur on his social platforms.

Due to the current COVID-19 epidemic situation, communication between teachers and learners must be changed. Social Distancing is a necessary thing between learners and teachers. Online learning has therefore played a huge role in learning method on this day, but online learning has its limitations, with the teacher unable to observe the learners' behavior during study. According to a study by the Zhenghao et al. (2015) study of Coursera learners, only 4% of those enrolled completed one course. Statistics show that online learning has a very low number of students complete the course. The research team hypothesized that the learning characteristics of each learner are different. The research team wanted to design a system with a learning environment suitable for each learner. To provide learners with complete knowledge from learning in online classes. Learning system takes into the learning characteristics of the learners divided by the Index of Learning Style (ILS) (1) active-reflective, (2) visual-verbal, and (3) sequential-global. From the Index of Learning, it can be used to separate the learning behavior of each learner. This learning system will be a model of a learning system that can be adaptable base on learning behaviors and style of learners. In this paper, there will be a system development section describing The Overall Structure of the Adaptive Learning EcoSystem and Content of Learning EcoSystem (LES) and describes about the experiment and result.

In addition, this study looks further to the challenges of promoting this system to digital STEM in college with a variety of applications integrating with different learning disciplines, e.g. Language learning, Social studies, Computer, etc. These challenges focus on making STEM on digital platforms by utilizing the benefits on the proposed system.

2. Related Literature

2.1 Learning Preference Analysis

Many researches and studies on pedagogy have validated that learners best achieve from learning through a teaching pattern that matches their own learning style the most (Bajraktarevic, Hall & Fullick, 2003). Learning style refers to the preferences and attributes of a learner that facilitate his learning process and understanding on a subject. Oftentimes, the term "learning style” and “learning preferences” are interchangeable (Phung et al., 2018).
Among various models and frameworks that aim to determine learners’ types of learning based on various descriptions and classifications, the Index of Learning Styles (ILS) is a set of questions specifically designed to identify types of learners based on the four dimensions classified in the Felder-Silverman model (Felder & Soloman, 2001). ILS consists of 44 questions that target to point out learners’ affections between two contrasts in the four dimensions which are (1) active-reflective, (2) sensing-intuitive, (3) visual-verbal, and (4) sequential-global (Phung et al., 2018). (1) Active learners enjoy actively trying things out while reflective learners like to think and reflect on materials, (2) sensing learners prefer concrete facts and procedures while intuitive learners learn through abstractions such as theories and ideas, (3) learners with visual preference learn best through pictures, charts and diagrams while those with verbal preference prefer written or spoken textual representations, (4) sequential learners understand things through small incremental steps while global learners comprehend in holistic views or big pictures (Graf et al., 2006).

There are a number of researches conducted to verify the reliability and validity of ILS. The results from the studies of Zywno (2003), Livesay et al. (2002) and Felder et al. (2005) suggested that ILS is in fact reliable and suitable for assessing learning styles (Felder & Spurlin, 2005). The recent utilization of ILS can also be found in many contemporary approaches and strategies for e-learning. For example, with an integration of J48 data mining algorithm, Nongkhai et al. (2015) presented a framework for e-learning recommendation by analyzing learners based on ILS. (Nongkhai & Kaewkiriya, 2015) The stated framework aimed to determine the best learning styles of learners.

The implementation of ILS by identifying learners’ behaviors according to each contrast end in four dimensions can help promote the process of determining a more precise learning style in an adaptive learning system.

2.2 Social Learning Analytics

The internet revolution has built up a complex network of vast interconnections among people of all ages, especially younger generations. The interactions among these people on social networks such as Facebook generate a tremendous amount of useful data on a daily basis. Some of this data initially comes from friending, liking, posting, sharing, etc. which are further mined and analyzed into valuable statistics, patterns and insights that can be applied in many fields of specializations.

With the focus on analyzing and utilizing such data in the field of learning, Social Learning Analytics (SLA) can benefit the learning processes through five possible approaches. (1) Social network analytics: analyzing the relationship among people to determine the society, (2) Discourse analytics: analyzing language, communication, and knowledge formation, (3) Content analytics: analyzing the content that users generated, (4) Disposition analytics: finding learning motivation that characterize online social media, and (5) context analytics: mobile processing that can access and understand the context of users. (Shum & Ferguson, 2012)

The applications of social learning analytics (SLAs) can be found across a variety of works and research topics by many contemporary researchers. Li et al. (2015) applied social learning analytics by examining social relations and different behaviors among users to increase the efficiency of the recommendation system for online learning communities. Zhou et al. (2016) deployed social learning analytics (SLA) to design and propose an Open Learning Platform in which the stakeholders, i.e. learners and instructors are provided more individualized support and services.

The differences between individual learners needed to enhance adaptive learning systems can be better determined with an inspection into the aspects of their social networking platforms.

2.3 Personalized Learning for 21st Century Learners

In this age of information, it is rational to argue that the classical "one-size-fits-all" model of education is no longer relevant for learners in the 21st century (McFarland, 2018). Owing to vast digitalization, providing a more personalized learning experience for each individual learner is within reach. Personalized learning eases the learning processes of learners by lessening their learning hassles and taking advantage of their cognitive traits, personalities and learning preferences.
In fact, "personalized learning (PL)" is an umbrella term used by many academic scholars and researchers to broadly refer to concepts and approaches that involve the use of learners’ personal attributes to enhance the learning processes. (Groff, 2017) Some of the most common technologies and methodologies related to PL include (1) Adaptive Learning Environments: response to learner inputs and interactions, (2) Cognitive Analytics: uses machine learning on existing data to build a self-learning feedback loop, (3) Learning Analytics: analyze data of learners in order to understand and optimize the learning environments, (4) Intelligent Tutoring Systems: simulate computer-aided tutoring instructions, (5) Educational Data Mining: data mining for educational purpose, etc. (Groff, 2017)

As personalized learning becomes a more thrilling alternative for learning in the 21st century, a large number of researches and proposals that aim to represent such learning have emerged. For instance, Herath & Jayaratne (2018) presented the use of web mining techniques, i.e. analysis on learners’ usages and behaviors on web navigation and web contents to exclusively provide a more personalized learning experience compared to traditional e-learning which provides the same content for all of its learners. The personalized recommendations intend to motivate learners by offering them courses that match their needs and expectations. Similarly, Muruganandan & Srinivasan (2014) proposed a method to provide adaptive personalized learning contents for learners based on the learning analytics of their profiles combined with sequential pattern data mining techniques.

Ultimately, the primary goal of personalized learning is to establish a learning structure that accounts for the adaptability and adjustments for each individual learner in the 21st century.

3. System Development

Learning EcoSystem (LES) is an adaptive learning system regarding digital security that implements Hybrid Learning Diagnostic Approach (HLDA) as its diagnostic process. HLDA is deployed in the initial learning module of LES in order to diagnose and detect learners' learning styles. In the initial learning module, learners' profile data such as gender and data representing their five most recent Facebook posts are collected with learners' permission. Learners are then continued to be diagnosed by engaging with a story-based learning content regarding cyber threat which consists of various user interactions such as characters, situations, communications, etc. The data collected from these two diagnoses are then analyzed according to the criteria in the Index of Learning Style (ILS) into 3 dimensions (1) active-reflective, (2) visual-verbal, and (3) sequential-global. One indication from each dimension can be combined into 8 different sets of classification where each set indicates one unique learning style. The learning styles detected with HLDA then act as a determiner for the conveyance style of subsequent learning modules of which the learners will receive.
The main objective of the Learning EcoSystem (LES) is to deliver learners, primarily freshman students at Mae Fah Luang University, the information regarding "Digital Security." LES consists of four main learning modules. The first learning module introduces the awareness and danger of cyber threat, the second module covers its precaution and prevention, the third suggests the laws and penalty regarding cybercrime, and lastly the fourth learning module presents the issues regarding of cyberbullying and game addiction.

LES is a web-based learning system that is structured according to the client-server model. This means learners interact with the learning system through web browsers such as Google Chrome, Safari, Internet Explorer, etc. on the “client” side of the application. These interactions on the client side trigger requests for services provided by the “server”, for example, services to retrieve or update data resources.

Table 1. Contents of LES

<table>
<thead>
<tr>
<th>Learning Modules</th>
<th>Learning Objectives</th>
<th>Story-based Content</th>
<th>Resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module 1</td>
<td>This module offers the definition, statistics, and types of cyber threat that commonly occur e.g. 9 types of computer malwares</td>
<td>Starting with an introduction from a character, this module is further divided into 3 units. The transition between each unit is carried out by a conversation from the characters while learners are given minor activities such as prompt questions to solve.</td>
<td>The first unit offers the definition of cyber threat, the second one presents its categories, and the third gives a concrete case study. In addition to verbal descriptions, each unit explains the materials with relevant infographics, images and videos.</td>
</tr>
<tr>
<td>Module 2</td>
<td>This module presents methods and procedures an individual can follow to keep oneself and the public safe from the risk of cyber threat e.g. 10 ways of cyber threat prevention</td>
<td>This module begins with an introduction of the cyber threat by a character. The module is divided into 3 smaller units in order to suggest 3 different groups of cyber prevention. Learners are continuously engaged with a prompt question about the prevention methods at the end of each unit.</td>
<td>Dividing into 3 units, the first provides 10 general ways to prevent cyber threat, the second presents 12 protection methods for organizations, and lastly the third offers 6 ways of cyber prevention for the general public. All sets of prevention approaches are listed and explained through infographics.</td>
</tr>
<tr>
<td>Module 3</td>
<td>This module provides knowledge regarding computer related laws to prevent individuals from unknowingly violating computer crimes e.g. the computer crime act (CCA) of Thailand</td>
<td>This module starts with an introduction of computer laws by a character. Dividing into 3 units, this module aims to provide firstly why computer related laws are needed, secondly what they are, and</td>
<td>The first unit of this module provides the definition and purpose of the computer crime act, the second unit offers a glimpse into the laws and penalty, and the third one presents a case study example. The</td>
</tr>
</tbody>
</table>
Lastly an example case of a computer crime. A prompt question regarding the content in each unit is brought out by a character alongside some conversations. Materials are explained through the use of images, infographics and videos.

<table>
<thead>
<tr>
<th>Module 4</th>
<th>This module informs learners the potential dangers of cyberbullying and game addictions including methods and approaches to prevent them from happening e.g. 6 main types of cyberbullying and how to prevent them.</th>
</tr>
</thead>
<tbody>
<tr>
<td>This module starts with an introduction of cyberbullying and game addiction by a character. Learners are asked whether they have encountered cyberbullying and game addiction in their life.</td>
<td></td>
</tr>
<tr>
<td>Dividing into 4 different units, the first one describes the definition of cyberbullying, the second unit presents 7 ways to prevent cyberbullying, the third explains game addiction and the fourth unit offers 4 ways to prevent game addiction. The explanations are assisted by icons and images while the prevention approaches are presented through infographics.</td>
<td></td>
</tr>
</tbody>
</table>

That are stored in the database. The client side of LES is built using basic web technology such as HTML, CSS and Javascript. The server side, on the other hand, is built on Node.js with Express framework to read and write data in a MongoDB database and it is deployed as a container using Docker. The client sends and retrieves data from the server using AJAX (Asynchronous Javascript And XML) techniques.

![Figure 2. The Overall Structure of Adaptive Learning EcoSystem](image)

Figure 2 describes the diagnosis processes implemented in the LES system. The first screen capture above shows how the most recent Facebook posts which learners share on their Facebook profile are collected as an initial diagnostic process. Afterwards, they are continued to be diagnosed with ILS.
which is presented through a story-based interaction. For example, as described in the figure, learners are asked by the two characters whether they mostly prefer reading books or watching movies with the aid of relevant visualization. Moreover, as a prompt question to test learners’ engagement and understanding, the third screen capture shows how learners can interact and respond to the question. Lastly, the fourth image displays what kind of assessment activity learners will receive at the end of each learning module.

Figure 3 briefly describes how the contents in LES are presented to learners with story-telling as well as adaptive techniques. The first screen capture shows how a short introduction regarding cyber threats is directly addressed to learners in second-person sentences. After introduction, the learning materials are presented to each learner according to his or her learning style detected in the diagnosis in module one. For example, as shown in the second image, learners may receive video or infographic explanations depending on their learning style. Moreover, the third image describes an assignment task and submission form learners will receive after finishing the learning materials. Finally, the fourth screen capture shows how learners are greeted by characters and given implications regarding the next learning module.

![Figure 3. The Overall Structure of Adaptive Learning EcoSystem](image)

In addition to the learning system which provides the learning materials concerning “Digital Security”, LES also has its own analysis system for the teachers who maintain and monitor the resulting data of learners. This system provides data visualization representing learners’ gender ratio, average time spent, average progress, scores (average, max, min, medium), and number of learners in each dimension of ILS, and in each learning style (Q). For example, the total number of learners alongside a donut chart representing its male-female ratio are shown in the first screen capture. To its right side are data showing the average time spent of all learners for each learning module, the average progress, as well as average, maximum, medium and minimum scores respectively. The total number of learners in each dimension of ILS are displayed numerically while that of the learning styles (Q) are displayed in a bar chart as shown in Figure 4.
4. Experiment and Results

4.1 Experimental Design

This experiment aims to study effectiveness of LES to learning preference by collecting learning assessment, feedbacks, and satisfactions from learners. Primarily freshman students at Mae Fah Luang University were participated in the experiment. Number of 1,487 students enrolled in an introduction to information technology and data science course. The participants were divided into 2 groups by purposive sampling. (1) An experimental group included 786 students which are 330 males and 456 females. (2) A control group included 701 students which are 273 males and 428 females.

Research instruments in this experiment are (1) Pretest and Posttest. (2) Learning attitude & satisfaction evaluation. The parallel tests in this learning evaluation includes 10 questions from learning modules using multiple-choice questions with good discrimination power and medium difficulty. The attitude & satisfaction evaluation consists of 20 questions with Likert Scale and open-ended questions.

The experimental steps are purposive sampling, pretesting, learning, post testing, collecting data and evaluation. First, all participants had taken 30 minutes of pretest before they studied the first learning module. Second, the experimental group studied on LES while the control group studied on a traditional learning system. Then all participants took 30 minutes of posttest after they had finished the four learning modules. Finally, the participant evaluated the learning attitude and satisfaction in 4 domains which are (1) Learning analytics (2) Learning media and activity (3) System usability and performance (4) System acceptance.

4.2 Results

4.2.1 Pretest & Posttest Result

The result of pretest and posttest from both sampling group found that the experimental group (M = 8.26, SD = 2.52) had higher score than the control group (M = 6.04, SD = 1.87) with a statistical significantly (t = 19.10, p = 0.001) as shown in table 2. After investigation more on the experimental group, indicating that the posttest result (M = 8.26, SD = 2.52) higher than pretest (M = 3.14, SD =
2.81) with a statistical significantly (t = 38.03, p = 0.001) as shown in table 3. Results indicated that LES had improvement of learning outcome.

Table 2. A Comparative Result of Posttest between LES and Traditional Learning System

<table>
<thead>
<tr>
<th>Group</th>
<th>Participants</th>
<th>M</th>
<th>SD</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental group (LES)</td>
<td>786</td>
<td>8.26</td>
<td>2.52</td>
<td>19.10</td>
<td>0.001***</td>
</tr>
<tr>
<td>Control group (Traditional)</td>
<td>701</td>
<td>6.04</td>
<td>1.84</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*** p < 0.001

Table 3. A Comparative Result of LES Between Pretest and Posttest

<table>
<thead>
<tr>
<th>Result</th>
<th>Participants</th>
<th>M</th>
<th>SD</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>786</td>
<td>3.14</td>
<td>2.81</td>
<td>38.03</td>
<td>0.001***</td>
</tr>
<tr>
<td>Posttest</td>
<td>786</td>
<td>8.26</td>
<td>2.52</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*** p < 0.001

4.2.2 Learning Attitude & Satisfaction

The evaluation of learning attitude and satisfaction from both sampling groups are shown in Table 4. Results show that the experimental group had higher score than the control group with a statistical significantly in 3 domains which are Learning Analytic, System Usability and Performance, and System Acceptance. The adjacent domain is Learning Media and Activity. The control group evaluated overall range 3.84 to 4.69 while the experimental group had higher score in overall range 4.37 to 4.73, indicating that the LES had better experienced to learners.

Table 4. A Comparative Result of Learning System

<table>
<thead>
<tr>
<th>Domain</th>
<th>Experimental group</th>
<th>Control group</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M ± SD</td>
<td>Meaning</td>
<td>M ± SD</td>
<td>Meaning</td>
</tr>
<tr>
<td>Learning analytic</td>
<td>4.68 ± 1.86</td>
<td>Highest</td>
<td>4.12 ± 2.77</td>
<td>High</td>
</tr>
<tr>
<td>Learning media and activity</td>
<td>4.73 ± 1.22</td>
<td>Highest</td>
<td>4.69 ± 1.38</td>
<td>Highest</td>
</tr>
<tr>
<td>System usability and performance</td>
<td>4.61 ± 2.82</td>
<td>Highest</td>
<td>4.32 ± 2.57</td>
<td>High</td>
</tr>
<tr>
<td>System acceptance</td>
<td>4.37 ± 2.49</td>
<td>High</td>
<td>3.84 ± 2.67</td>
<td>Medium</td>
</tr>
<tr>
<td>Overall</td>
<td>4.60 ± 1.63</td>
<td>Highest</td>
<td>4.24 ± 1.80</td>
<td>High</td>
</tr>
</tbody>
</table>

* p < 0.05, *** p < 0.001

5. Conclusion and Challenges of Digital STEM

As the significant score of the posttest, indicating that the adaptive learning system improves learning outcome. A learning analytic is one of the highest evaluation scores which brings attention of learning preferences to learners. The system dashboard of the learning analytic shows that most learners’ analytic results are visual, active, and sequence from the index of learning style.

This confirms that learners realize about personalized learning. The learners were excited about the learning style, even if they did not notice on when and how the analytic had worked. Therefore, a social media data can be blended to a learning analytic without an interruption of the learning process. One limitation of this research is the diagnosing of learning styles is not adaptability. Once the index of learning style is identified, learners could not change the preference. Thus, it is justifiable to feel bored.

A web-based learning system can be reached anytime and anywhere, thus the system can be utilized under the situation of COVID 19. Moreover, the learning media and activities are recommended for the high school students. Regardless of learning media and activity had highest
score, the LES did not differ from the traditional. The percentage of completed on learning from 1 to 4 are descending. It is possible that the designed may not be variety. Further studies are therefore necessary to design the effective learning media and activity.

In the near future, this proposed system can be applied in various learning situations. More specifically, this system is set to integrate with STEM learning activities on different learning fields of studies by taking the advantage of digital environment. The challenges to this integration would be as follows: 1) the design of learning activities that would require the API among digital platforms and 2) the implementation of digital STEM on different contexts of learners located in different places and times. Digital STEM is not only a new engaging way of STEM education, but also promoting the equality of education to all learners who cannot access to the STEM-based learning situations physically.

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Mathematics Motivation in Developing Countries: A Vietnamese Case Study

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Abstract: Mathematics motivation plays a significant role in improving mathematics education. However, there is a lack of study on the perception of Vietnamese high school postgraduate students towards mathematics motivation. This paper aims to fill this gap by examining the attitude of both male and female high school graduate students on mathematics motivation as well as comparing mathematics achievement based on gender in Vietnam. The study utilised the Academic Motivation Toward Mathematics Scale (AMTMS) for the questionnaire survey and data collection. The findings showed that there was a non-significantly difference between the male and female perception of mathematics motivation. There was also a non-significant difference between male and female in mathematics achievement. The paper also discusses incorporating technology in mathematics education to promote educators and students in teaching and learning mathematics.

Keywords: Mathematics education, mathematics motivation, gender difference, mathematics achievement.

1. Introduction

The studies of mathematics education and affected domain have been received attention from scholars and educators (Attard, Ingram, Forgasz, Leder, & Grootenboer, 2016). Individuals' emotions, beliefs and attitudes have been proved as a critical role in people's interest and response, in general, to mathematics and their employment of mathematics in their individual lives (OECD, 2013). A student who feels more confident with mathematics is more likely than others in using mathematics in the diverse contexts that they may experience (OECD, 2013). Also, a student who has positive emotions towards mathematics is participating better in learning mathematics than an individual who feels anxiety (OECD, 2013). Consequently, one of the main objectives of mathematics education is to develop students' emotions, beliefs and attitudes in supporting them more likely to apply the mathematics and learn more mathematics for their individual and social benefits (OECD, 2013).

In mathematics education research, the study of engagement and motivation seems to be a growing area of interest (Attard et al., 2016). Lim and Chapman (2015a) adapted the academic motivation scale (AMS) (Vallerand et al., 1992) to develop the academic motivation toward mathematics scale (AMTMS).

The academic motivation can be classified into three categories based on the self-determination theory, including amotivation, extrinsic motivation and intrinsic motivation (E. L. Deci & Ryan, 1985). Amotivation refers to the absence of intent to pursue an activity because an individual does not value an activity, feel incompetent or feel unable to obtain a desirable outcome (Edward L. Deci & Ryan, 2000). Intrinsic motivation refers to pursue an action due to its satisfactions (Edward L. Deci & Ryan, 2000) and it can be referred to the scenario that people participate in activities for the pleasure and satisfaction that are obtained in the engagement process (Lim & Chapman, 2015b). Extrinsic motivation, however, includes the cline between amotivation and intrinsic motivation, including external regulation, introjected regulation, and identified regulation (Edward L. Deci & Ryan, 2000).

External regulation can be seen as a form of extrinsic motivation in which individual behaves to achieve the desired outcomes, for instance, avoiding a threat of punishment or tangible rewards (Edward L. Deci & Ryan, 2000). Introjection can be seen as a more internal form of extrinsic motivation...
than external regulation, and it occurs when people feel that they 'ought to' engage in activities (Lim & Chapman, 2015b; Wang, Hagger, & Liu, 2009). In comparison to external regulation that has poor maintenance and transfer, an introjection has been partly internalised and consequently more likely to maintain over time; however, they stay a relatively unstable (Edward L. Deci & Ryan, 2000; Koestner, Losier, Vallerand, & Carducci, 1996). Identification can be seen as the most internal form of extrinsic motivation (Lim & Chapman, 2015b). It does not involve in identifying the importance of behaviours but also to integrating those identifications with other aspects of the self (Edward L. Deci & Ryan, 2000).

Regarding mathematics motivation, several studies examined the relationships between mathematics motivation and mathematics achievement. Motivation has been notified to positively associate with a desirable outcome, such as high academic performance in education (Gottfried, Marcoulides, Gottfried, Oliver, & Guerin, 2007). However, the lack of academic motivation negatively affects education outcomes (Barkoukis, Tzourbatzoudis, Grouios, & Sideridis, 2008). Amotivation is related to a large number of highly negative outcomes (Edward L. Deci & Ryan, 2000). Lim and Chapman (2015b) found out that amotivation and intrinsic motivation statistically associate with mathematics achievement for both male and female students who enrolled in a top pre-tertiary institution in Singapore. Also, intrinsic motivation has been proved to be the most significant affective domain for females in achieving better mathematics performance in the long term (Lim & Chapman, 2015b). Moreover, identification positively affects mathematics achievement (Lim & Chapman, 2015a). However, as noted by Lim and Chapman (2015b) their findings were based on Chinese sample in Singapore, further studies on students from other countries and cultures are necessary.

Furthermore, gender differences are still a concern in mathematics education. There was a concern regarding an under-representation of a female in the Science Technology, Engineering, and Mathematics (STEM) fields as well as year 12 mathematics in advanced and intermediate levels (Attard et al., 2016). Also, gender differences were found in the study of the relationship between mathematics motivation and mathematics achievement (Lim & Chapman, 2015b). Through identifying the affective domains in mathematics education, educators, especially mathematics teachers, may apply different intervention methods assisting students in improving their self-confidence in mathematics. Thus, this may lead to improve mathematics achievement. However, there is a lack of empirical research into the perception of students on mathematics motivation and performance considering the gender, especially in Vietnam. Therefore, this paper aim is to fill this gap by examining the attitude of both male and female high school postgraduate students on mathematics motivation as well as comparing the mathematics achievement based on the gender in the Vietnamese context.

2. Research Methodology

Section 2 presents an overview of the sample size, data collection instrument, and data analysis method.

2.1 Participants

The target respondents were high school postgraduate students who participated in the National High School Graduation Examination, 2019. The exam was administrated by the Ministry of Education and Training at the end of year 12 to get a High School Graduation Certificate. The results of the exam were also used to apply for further studies, such as college or university. There were 305 males, 367 females and 8 others in the final sample (N = 680). Among participants, 93.8% of them have been studying a higher education, in which, 92.2% enrolled in a University. Interestingly, 85.9% of participants who have reported that they used their mathematics scores in their combination subjects to apply for studying at university. In Vietnam, universities often used scores of several subjects in the National Examination to select students.
2.2 Data Collection Instrument

The study utilised the Academic Motivation Toward Mathematics Scale (AMTMS) (Lim & Chapman, 2015a). The AMTMS was developed based on the academic motivation scale (AMS) (Vallerand & Blissonnette, 1992) which is one of the most commonly adopted instruments for measuring academic motivation (Lim & Chapman, 2015b). The AMTMS includes amotivation (AMOT) (four items), external regulation (EMER) (four items), introjection (EMIN) (four items), identification (EMIT) and intrinsic motivation to accomplish (IMTA) (5 items) (Table 1). All these items were used as the answers to the AMTMS's main question - Why do you spend time studying mathematics? The participants were asked to give their opinions on these items according to a 5-point response scale ranging from 1 (strongly disagree) to 5 (strongly agree). Table 1 presents the measurement items as well as its mean and standard deviation.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SE</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Why do you spending time studying mathematics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>motivation</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Honestly, I don't know; I feel that it is a waste of time studying mathematics.</td>
<td>1.76</td>
<td>0.032</td>
<td>0.840</td>
</tr>
<tr>
<td>I can't see why I study mathematics and frankly, I couldn't care less.</td>
<td>1.90</td>
<td>0.033</td>
<td>0.858</td>
</tr>
<tr>
<td>I don't know; I can't understand what I am doing in mathematics.</td>
<td>1.92</td>
<td>0.033</td>
<td>0.856</td>
</tr>
<tr>
<td>I am not sure; I don't see how mathematics is of value to me.</td>
<td>1.88</td>
<td>0.033</td>
<td>0.854</td>
</tr>
<tr>
<td>Cronbach's Alpha: 0.859</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>external regulation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Because without a good grade in mathematics, I will not be able to find a high-paying job later on.</td>
<td>2.96</td>
<td>0.042</td>
<td>1.085</td>
</tr>
<tr>
<td>In order to obtain a more prestigious job later on.</td>
<td>3.28</td>
<td>0.037</td>
<td>0.960</td>
</tr>
<tr>
<td>Because I want to have &quot;the good life&quot; later on.</td>
<td>3.62</td>
<td>0.036</td>
<td>0.937</td>
</tr>
<tr>
<td>In order to have a better salary later on.</td>
<td>3.54</td>
<td>0.037</td>
<td>0.953</td>
</tr>
<tr>
<td>Cronbach's Alpha: 0.872</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>introjected regulation Cronbach's Alpha: 0.810</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Because of the fact that when I do well in mathematics, I feel important.</td>
<td>3.89</td>
<td>0.030</td>
<td>0.789</td>
</tr>
<tr>
<td>Because I want to show to others (e.g., teachers, family, friends) that I can do mathematics.</td>
<td>3.67</td>
<td>0.034</td>
<td>0.882</td>
</tr>
<tr>
<td>To show myself that I am an intelligent person.</td>
<td>3.38</td>
<td>0.037</td>
<td>0.957</td>
</tr>
<tr>
<td>Because I want to show myself that I can do well in mathematics.</td>
<td>3.49</td>
<td>0.034</td>
<td>0.880</td>
</tr>
<tr>
<td>Cronbach’s Alpha: 0.890</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>motivation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Because I think that mathematics will help me better prepare for my future career.</td>
<td>3.76</td>
<td>0.034</td>
<td>0.887</td>
</tr>
<tr>
<td>Because studying mathematics will be useful for me in the future.</td>
<td>3.91</td>
<td>0.032</td>
<td>0.828</td>
</tr>
<tr>
<td>Because I believe that mathematics will improve my work competence.</td>
<td>3.95</td>
<td>0.032</td>
<td>0.831</td>
</tr>
<tr>
<td>Because what I learn in mathematics now will be useful for the course of my choice in university.</td>
<td>3.68</td>
<td>0.035</td>
<td>0.902</td>
</tr>
<tr>
<td>Cronbach's Alpha: 0.908</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variable</td>
<td>Mean</td>
<td>SE</td>
<td>SD</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>Because I want to feel the personal satisfaction of understanding mathematics.</td>
<td>4.09</td>
<td>0.031</td>
<td>0.804</td>
</tr>
<tr>
<td>For the pleasure I experience when I discover new things in mathematics that I have never learnt before.</td>
<td>4.04</td>
<td>0.030</td>
<td>0.791</td>
</tr>
<tr>
<td>For the pleasure that I experience in broadening my knowledge about mathematics.</td>
<td>4.01</td>
<td>0.031</td>
<td>0.808</td>
</tr>
<tr>
<td>For the pleasure that I experience when I learn how things in life work, because of mathematics.</td>
<td>3.85</td>
<td>0.033</td>
<td>0.856</td>
</tr>
<tr>
<td>For the pleasure that I experience when I feel completely absorbed by what mathematicians have come up with.</td>
<td>3.58</td>
<td>0.035</td>
<td>0.921</td>
</tr>
<tr>
<td>Mathematic score in the National High School Graduation Examination, 2019</td>
<td>7.28</td>
<td>0.051</td>
<td>1.343</td>
</tr>
</tbody>
</table>

2.3 Data Analysis Method

The study used SPSS for data analysis. Descriptive statistic was used to examine the mean values, standard errors (SE) and standard deviations (SD). Reliability analysis was conducted to assess internal consistency. One-way ANOVA was conducted to see whether there is a significant difference in perception between male and female on measurement items as well as mathematics achievement. Cronbach's alpha values of measurement scales are from 0.810 to 0.908 (Table 1), which is considered very good or excellent (Kline, 2015). Therefore, the measurement scales appear to consist of a set of consistent variables for observing the meaning of the measurement constructs.

3. Results and Discussion

This section presents the preliminary findings of the study, comparative analysis based on the gender about the perceptions regarding mathematics motivation, and discussion about applying technologies in mathematics education.

3.1 Preliminary Finding

This section examines and interprets the mean values of all measurement items calculated from the whole sample.

As shown in Table 1, the amotivation measurement items had mean values of around (1.76 – 1.92), which were significantly lower than 3.0 (neutral point), AMOT1 \( t(679) = -38.403, p < 0.001 \), AMOT2 \( t(679) = -33.351, p < 0.001 \), AMOT3 \( t(679) = -32.997, p < 0.001 \) and AMOT4 \( t(679) = -34.292, p < 0.001 \). These data indicated that the respondents strongly disagree with the statements regarding amotivation measurement items when answering the main question. The statements are a waste of time studying mathematics (AMOT1), cannot see why I study mathematics (AMOT2), cannot understand what I am doing in mathematics, and do not see how mathematics is of value (AMOT3).

Overall, the mean values of external regulation items compared with 3.0 (neutral point) were mixed. The mean value of EMER1 (2.96) \( t(679) = -0.990, p = 0.323 \) was around 3.0, which represented 'neutral point', and indicated that most students did not agree or disagree to the statement that without a good grade in mathematics, they will not be able to find a high-paying job later. However, the mean values of EMER2 (3.28), EMER2 (3.62) and EMER4 (3.54) \( t(679) = 7.632, p < 0.001 \) were above the medium level of 3.0, indicating that students spending time to study mathematics because they want to obtain a more prestigious job (EMER2), 'the good life' (EMER3) and better salary...
(EMER4).

Regarding introjection measurement items, EMIN, the mean values (3.49 ?? 3.89) were all above the medium level of 3.0, \( t(679) = 10.298 \) or \( p < 0.001 \). It indicates that students strongly believed that their feeling of studying mathematics had been motivated them. For instance, these included feeling important when doing well in mathematics (EMIN1), showing others that they can do math (EMIN2) as well as showing themselves as an intelligent person (EMIN3) and showing that they can do well in math (EMIN4).

In terms of identification, EMIT, the mean values (3.68 ?? 3.91) were significantly higher than 3.0 \( t(679) = 19.648 \) or \( p < 0.001 \). It means that most students strongly agreed that they were studying mathematics with the belief about the benefits that mathematics may offer. They include a better preparing for their future career (EMIT1), useful in the future (EMID2), improving their work competence (EMID3) and useful for their future study (EMID4).

Regarding intrinsic motivation, IMTA, the mean values (3.58 ?? 4.09) were significantly higher than 3.0 \( t(679) = 16.453 \) or \( p < 0.001 \). It suggests that the pleasure and satisfaction were also a motivation for students to study mathematics, such as feeling the personal satisfaction of understanding mathematics (IMTA4) and for pleasure (IMTK2, IMTK3, IMTS2 and IMTS3).

In this study, the average mathematics score of respondents was relatively high, 7.28 out of 10 (see Table 1). The demographic information can explain this finding. According to the survey, 93.8% of participants have studied at university. 85.9% of respondents used mathematics score as a criterion to be selected for studying at university. So, mathematics was a primarily focused subject for those students as they needed a good mark to be able to get in their preference’s university.

3.2 Comparison of Male and Female Samples

In addition to the initial results presented in the last section, this paper also undertook a comparative analysis based on the gender about the perceptions regarding mathematics motivation measurement items as well as the mathematics achievement of male and female.

To determine whether there was any difference in the perception of the mathematics motivation items as well as the mathematics achievement regarding gender, one-way ANOVA was conducted. In ANOVA, the F-ratio is considered as an essential test statistic indicator (Allen, Bennett, & Heritage, 2014). There is a statistically significant difference between the groups being compared when the F-ratio is statistically significant. Besides, the effect size is an essential test statistic (Allen et al., 2014). In this paper, the authors used the eta-squared \( \eta^2 \) which is an index of the omnibus effect size. Eta-squared \( \eta^2 \) is computed by dividing the SS_between (between-group sum of squares) by the SS_total (total sum of squares) (Allen et al., 2014). It should be noted that when \( \eta^2 = 0.01 \) can be considered small, \( \eta^2 = 0.059 \) can be considered medium and \( \eta^2 = 0.138 \) can be considered large (Cohen, 1988). The results of the one-way ANOVA are presented in Table 2.

As presented, six variables had a statistically significant F-ratio (EMER3, EMER4, EMIN4, IMTA4, IMTK2, and IMTK3). The results suggest that, initially, the difference in the mean values of those variables was significantly different between the two groups. However, among those variables, all of those had small \( \eta^2 < 0.01 \) or medium \( \eta^2 < 0.059 \) effect size. Therefore, it can be concluded that there was a non-significantly difference between male and female perceptions of mathematical motivation. Furthermore, as illustrated in Table 2, there was a non-significant difference between male and female in mathematic achievement \( F(1, 670) = 0.47, p = 0.829, \eta^2 = 0.000 \). This finding was slightly different to that of Attard et al. (2016) who concerned about under-representation of a female in the STEM and year 12 intermediate and advanced mathematics. This difference may be explained by the fact that, in Vietnam, mathematics can be seen as one of the most important subjects at school. Parents, caregivers, and teachers often encourage all students to study and spend more time in mathematics. Another explanation may be that most of the respondents in this study reported that their mathematics scores were used as a criterion to be selected for studying at university. So, mathematics was a primarily focused subject while they were studying at high school.
### Table 2. One-way ANOVA Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>F</th>
<th>Sig.</th>
<th>Mean Male</th>
<th>Mean Female</th>
<th>Δ Mean</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMOT1</td>
<td>3.124</td>
<td>0.078</td>
<td>1.81</td>
<td>1.70</td>
<td>0.11</td>
<td>0.005</td>
</tr>
<tr>
<td>AMOT2</td>
<td>2.949</td>
<td>0.086</td>
<td>1.96</td>
<td>1.84</td>
<td>0.12</td>
<td>0.004</td>
</tr>
<tr>
<td>AMOT3</td>
<td>0.702</td>
<td>0.402</td>
<td>1.94</td>
<td>1.89</td>
<td>0.05</td>
<td>0.001</td>
</tr>
<tr>
<td>AMOT4</td>
<td>1.644</td>
<td>0.200</td>
<td>1.92</td>
<td>1.83</td>
<td>0.09</td>
<td>0.002</td>
</tr>
<tr>
<td>EMER1</td>
<td>0.701</td>
<td>0.402</td>
<td>2.92</td>
<td>2.99</td>
<td>-0.07</td>
<td>0.001</td>
</tr>
<tr>
<td>EMER2</td>
<td>5.178</td>
<td>0.023</td>
<td>3.20</td>
<td>3.37</td>
<td>-0.17</td>
<td>0.008</td>
</tr>
<tr>
<td>EMER3</td>
<td>9.013</td>
<td>0.003</td>
<td>3.50</td>
<td>3.72</td>
<td>-0.22</td>
<td>0.013</td>
</tr>
<tr>
<td>EMER4</td>
<td>6.322</td>
<td>0.012</td>
<td>3.44</td>
<td>3.62</td>
<td>-0.18</td>
<td>0.009</td>
</tr>
<tr>
<td>EMID1</td>
<td>1.994</td>
<td>0.158</td>
<td>3.72</td>
<td>3.81</td>
<td>-0.09</td>
<td>0.003</td>
</tr>
<tr>
<td>EMID2</td>
<td>2.402</td>
<td>0.122</td>
<td>3.62</td>
<td>3.73</td>
<td>-0.11</td>
<td>0.004</td>
</tr>
<tr>
<td>EMID3</td>
<td>0.001</td>
<td>0.971</td>
<td>3.34</td>
<td>3.42</td>
<td>-0.08</td>
<td>0.000</td>
</tr>
<tr>
<td>EMID4</td>
<td>0.449</td>
<td>0.503</td>
<td>3.66</td>
<td>3.71</td>
<td>-0.05</td>
<td>0.001</td>
</tr>
<tr>
<td>EMIN1</td>
<td>0.053</td>
<td>0.819</td>
<td>3.89</td>
<td>3.90</td>
<td>-0.01</td>
<td>0.000</td>
</tr>
<tr>
<td>EMIN2</td>
<td>2.522</td>
<td>0.113</td>
<td>3.62</td>
<td>3.73</td>
<td>-0.11</td>
<td>0.004</td>
</tr>
<tr>
<td>EMIN3</td>
<td>0.956</td>
<td>0.329</td>
<td>3.34</td>
<td>3.42</td>
<td>-0.08</td>
<td>0.001</td>
</tr>
<tr>
<td>EMIN4</td>
<td>5.068</td>
<td>0.025</td>
<td>3.42</td>
<td>3.57</td>
<td>-0.15</td>
<td>0.008</td>
</tr>
<tr>
<td>IMTA4</td>
<td>12.106</td>
<td>0.001</td>
<td>3.99</td>
<td>4.20</td>
<td>-0.21</td>
<td>0.018</td>
</tr>
<tr>
<td>IMTK2</td>
<td>7.315</td>
<td>0.007</td>
<td>3.96</td>
<td>4.13</td>
<td>-0.17</td>
<td>0.011</td>
</tr>
<tr>
<td>IMTK3</td>
<td>9.330</td>
<td>0.002</td>
<td>3.92</td>
<td>4.11</td>
<td>-0.19</td>
<td>0.014</td>
</tr>
<tr>
<td>IMTS2</td>
<td>1.082</td>
<td>0.299</td>
<td>3.82</td>
<td>3.89</td>
<td>-0.07</td>
<td>0.002</td>
</tr>
<tr>
<td>IMTS3</td>
<td>0.000</td>
<td>0.988</td>
<td>3.59</td>
<td>3.59</td>
<td>0</td>
<td>0.000</td>
</tr>
<tr>
<td>MA</td>
<td>0.047</td>
<td>0.829</td>
<td>7.28</td>
<td>7.30</td>
<td>-0.02</td>
<td>0.000</td>
</tr>
</tbody>
</table>

3.3 **Effective Technology Use to Improve Mathematics Engagement**

Applying technology in mathematics education allows teachers and students to collaborate for improving learning experience that supports flexible thinking and problem-solving. With the development of technology and the Internet, websites and apps that provide manipulative options, for instance, geoboards, number frames, and number lines should be developed and used to support students to understand the mathematics concepts. Also, websites and virtual whiteboards can promote self-reflection for students; thus, these technologies may allow students making their learning visible and sharing and connecting ideas. Furthermore, virtual reality can be applied in mathematics education to help students to see three-dimensions (3D) geometry. These technologies, as mentioned earlier, can support educators in teaching and encourage students to effectively develop their problem solving skills while studying mathematics.

### 4. Conclusion

This study explored the perception of high school graduate students based on Academic Motivation Toward Mathematics in Vietnam. The study also looked at the gender difference toward mathematics motivation as well as mathematics achievement. The preliminary finding revealed that most of the respondents have studied at a University (92.2%) after graduated high school. Moreover, 85.9% of participants reported that they used their mathematics scores, together with scores of other subjects to apply for further study at university.

Furthermore, most respondents thought that studying mathematics is not a waste of time, and they understand what they did in mathematics as well as the values that mathematics may bring to their personal life. Students studied mathematics as they want to get a more prestigious job, good life and a better salary in the future. They also believed that their personal feeling of studying mathematics had been motivated them, for instance, feeling important when doing well in mathematics, showing others...
that they can do mathematics and showing themselves as an intelligent person. Notably, participants believe that studying mathematics could be better for their future study and career. Moreover, students reported that the pleasure and satisfaction were also a motivation for students to study mathematics. Besides, through one-way ANOVA analysis, there was a non-significantly difference between the male and female perception of mathematics motivation. There was also a non-significant difference between male and female in mathematics achievement.

There was a limitation on this study. Initially, the study did not target any particular group of respondents; anyone who participated in the National High School Graduation Examination, 2019 were welcome. However, the result reported that most of the respondents have studied at a University. So, the finding may only be represented by this particular group and may not be generalised to all high school graduate students in Vietnam.

The further studies may look at different affective domains and its relationship with mathematics achievement for high school students as well as the intervention strategies to improve mathematics education for high school students. With the development of technology, future studies may investigate the effectiveness of incorporating technology in mathematics education.

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References


Trends of Instructional Research Using Biology Game: A Systematic Review of the Evidence during 2010-2019

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Abstract: Learning by using a game in science is becoming popular and it has been conducted in instructional research by many countries. Many researchers investigated instructional trends of using science games in several review articles. However, the review analysis emphasizing the use of educational game in biology is rarely found. As such, this paper aims to portray the trends of instructional research using biology games, both digital or non-digital, from 2010 to 2019 in Scopus indexed articles. Based on the reviews, the trends of game-based biology learning during the last ten years were raised gradually. In addition, the majority of the games used is simulation-like digital game. While most non-digital games were used is board game. The finding could be implied into development of technological and pedagogical solutions in a future of biology education.

Keywords: Serious game, educational game, game-based learning, digital game, biology gaming

1. Introduction

Many studies have used the potential of games to promote students’ affective domain of learning and increase their cognitive performance (Srisawasdi & Panjaburee, 2019). Using games in science learning activity is not a new phenomenon in education. Games had been implemented in school education as learning tools (Anderson & Barnett, 2011). Some studies also reported that using a game as a learning tool (game-based learning) and gamification significantly increased student motivation for learning (Cózar-Gutiérrez & Sáez-López, 2016; Pesare et al., 2016). Johnson et al. (2012) explained that games can make learners motivated because it transforms the boring learning into interactive learning. In term of instructional research, many researchers proved that using games in science class gave several educational benefits. For instances, Khenissi et al. (2015) stated that the games helps learners to understand the concept. Moreover, games also can stimulate the formation of mental structures from natural phenomena to become long-lasting and also show significant effects on students’ cognitive enhancement (Corredor et al., 2014; Khoiriah et al., 2016). Besides, games and simulations in science learning can improve learning quality in both formal and informal education (Muehrer et al., 2012). Also, Divjak & Tomić (2011) argued that a computer-based game affects attitude. Besides, games or ICT-based media can improve generic skills in science (Mulyani et al., 2016). As abovementioned, games have been chosen by educators and researchers in order to enhance the quality of instruction and to improve students’ learning outcomes.

To review trends and direction of game-based learning in science, Li and Tsai (2013) conducted an investigation to examine the use of game in science education from 2002 to 2013. They reported that there is a surge of interest in the use of serious games in context of science education. Many games were utilized to promote scientific knowledge or conceptual learning, while less than one third were implemented to facilitate the students’ problem-solving skills. Based on the previous review, there is no specific review analysis concerning the use of games in biology context before, and the research
related to biology game for learning still has many attractive things for educators and researchers. Therefore, this study aimed to review researchers on the use of educational biology games, and this systematic review is an essential for the future research. In this study, the questions were:

- How was the trend of using educational biology games from 2010 to 2019?
- What were the types of games published from 2010 to 2019?

2. Literature Review

2.1 Game-based Learning (GBL)

GBL refers to a student’s engagement with educational materials with enjoyment, which defines by rules and artificial conflict (Salen & Zimmerman, 2010). Instead of learning to play the game, GBL means learning through the game (Siang Ang, Avni, & Zaphiris, 2008). While Simões et al. (2013) explained that GBL is using games both in leisure and serious about enhancing and supporting learning. Games which is used to attempt the learning objectives rather than only entertainment is called serious game (Vorderer & Ritterfeld, 2009).

GBL has several elements or characteristics which differentiate the game with non-game. It is explained that game is a media audio-visual composed of several characteristics such as fun characteristics, feedback, rewards, and challenges (Li & Tsai, 2013). Prensky (2001b) also stated that the game must have six elements, which are rules, goals, feedback, challenge, interaction, and story or representation. Whereas Plass et al. (2015) explained that there are several game elements to improve the students or player engagement, namely learning objectives, game mechanics, narrative, visual aesthetics, incentives, and musical score. While Alexiou & Schippers (2018) argued that the game elements that are nested within three main layers: the game system (rules, mechanics), narrative (theme, story, characters), and aesthetics (audio-visual elements, fidelity, aesthetic choices).

GBL has the primary foundation, which is cognitive, motivation, affective, and sociocultural engagement with the subject matter (Plass et al., 2015). In the cognitive foundations, designers should consider how the game elements affect cognitive processing where cognitive engagement starts with attention (Alexiou & Schippers, 2018). There are several ways to facilitate cognitive processing, such as using scaffolding and interaction design (Mayer, 2016). From the motivation foundations, designers must focus on using specific elements in their educational games to engage and motivate students. While affective and sociocultural foundations focus on emotions, beliefs, and social and cultural factors (Plass et al., 2015).

2.2 Digital Game-based Learning (DGBL)

The advancement of computer and multimedia technologies provides students with opportunities to experience various situations, and to cope with problems encountered in daily life through DGBL (Tapingkae, Panjaburee, Hwang, & Srisawasdi, 2020). The definition of DGBL refers to the use of games for expected learning outcomes, which is the development of GBL in line with the rising of computers (Loh et al.,2015; Sanchez, 2019). Also, it is explained that DGBL is a combination of serious learning, fun, engagement, and interactive entertainment (Prensky, 2001a).

DGBL can achieve a constructivist learning goal by the constructivist conditions (Alexiou & Schippers, 2018). Although the foundation is similar to GBL, DGBL not only using specific games but using various such as games and gameplay, subjects and disciplines, and a variety of educational practices (Loh et al., 2015). Another research found that digital games significantly improved student learning compare to non-game conditions (Qian & Clark, 2016).

The foundations and game elements of DGBL same as GBL. To engage the students in DGBL, the designer must consider the game elements. Game elements influence in supporting learning and enhancing intrinsic motivation. Emotional engagement can be improved by narrative elements, while cognitive engagement can be enhanced by the challenge in-game mechanics (Alexiou & Schippers, 2018).
2.3 Gamification for Learning

In term of educational concept, gamification is not the same as the GBL or DGBL. Gamification is using game elements such as incentive systems to motivate and engage the players in the task or to continue particular behavior. GBL is known by using video games as learning tools (Loh et al., 2015.; Plass et al., 2015; Simões et al., 2013). Also, Kim, Song, Lockee and Burton (2018) stated that gamification related to the activities to solve the problems in learning and education. Simões et al. (2013) indicated that gamification in learning and teaching also includes serious games.

Instead of fun and enjoyment, gamification as an instructional approach is designed to enhance the effectiveness of student learning. The benefit of gamification is to increase student engagement and motivation, learning performance and academic achievement, improve recall and retention also to provide feedback on students’ progress and activity (Kim, Song, Lockee, & Burton, 2018). While for teachers the gamification helps to create challenges, set up the objectives, choose the proper game mechanics to be applied in the learning activity, recognize the students’ progress and use the competition to enhance valuable behaviors (Simões et al., 2013).

2.4 Previous Studies of Game-based Learning

A study about the trends in GBL cannot be separated from the previous research. As stated in (Cheng et al., 2015), fewer studies explicitly introduced the educational theoretical foundations for using serious games in science education or the instructional strategies coupled with the use of serious games. Also, several studies reveal that in the future, using GBL can promote the development of 21st-century skills (Qian & Clark, 2016). Another study result is that there is a high interest in using serious games in science from 2002 to 2013. At the time the role-playing game/ adventure was the most popular games based on the empirical studies (Cheng et al., 2015). While some studies underline the game mechanics or design must be considered when developed the game. As stated in Alexiou & Schippers (2018), outlines the role of narrative, aesthetics, and core game mechanics in facilitating higher learning outcomes through intrinsic motivation and engagement. While another research suggested that in designing a game, the challenges should be able to keep up learners' growing abilities and learning in GBL environments (Hamari et al., 2016).

3. Method

3.1 Data Collection

The study conducted by examining research papers in Scopus database from 2010 to 2019. By searching keywords (game) or (gamification) or (gamifying) and (learning) and (biology). A total of 257 papers were eligible for this study. Then, the unrelated topic papers were excluded from analysis become 127 papers. From 127 articles, there were 80 papers that irrelevance with the study. The final results received 47 papers. The documents were analyzed scrutiny to ensure reliability. Figure 1 displays the steps of selecting papers for data collection.
3.2 Coding Schemes

As stated in Chang and Hwang (2019), there are three major foci using game in science education which are game-used, pedagogical used and research method. In this study, to investigate the using game in biology learning include several dimensions namely the countries, major journal publishing, game types, learning strategies, research methods and the topics in biology game.

3.3 Game Types

The game is classified into eight categories which are Action, Adventure, Fighting, Puzzle, Role Playing, Simulations, Sports, and Strategy (Prensky, 2001c). While Renken, Peffer, Otrel-Cass, Girault, & Chiocarrello (2016) divide types into six categories, namely adventure games, role-playing games, action games, simulations, and strategy games, and virtual worlds.

Before we classify into those categories, in this review, the researchers divided games into three mains, which are digital games, non-digital games, and gamification. Digital games refer to computer games, while non-digital games refer to non-computer games. Gamification refers to use of game mechanics in the activity to solve the problems. In this review, games are categorized into nine types, which are adventure game, role-playing game, puzzle game, action game, simulations, strategy game, virtual world, quiz, and augmented reality.

4. Results and Discussion

4.1 Documents Per Year

Based on the documents per year (see Fig.2), paper publishing related educational biology games increased gradually. During the time, there are some peak points, which are in 2013, 2016, and 2018. The highest number was in 2018 stood at ten papers. Although there is a decline of 50% in 2017, overall, the graph shows the improvement trend.

In a discussion, the trend is in line with the previous research from 2007 to 2013 (Cheng et al., 2015), which stated that at the time, the number of articles published rose significantly. It was stated that educators in science education started to investigate the effectiveness of serious games. The other research also gives the same results (Cheng et al., 2015; Qian & Clark, 2016). Currently, it can be predicted that the interest of research in the future will continue to rise.
4.2 Types of Games

As stated by Prensky (2001c), there are several kinds of games. In this research, almost over 60% of papers investigated were digital games, while non-digital games and gamification were around 36% and 4% respectively. (see Fig.3).

To discuss the result obtained, the increasing development of digital game is influenced by the development of ICT and current learner’s characteristics, who are digital natives (living in the technology era) (Prensky, 2001a). Students prefer to use the technology (game) to learn instead of the traditional way.

This research also found gamification and non-digital game. During nine years, research about gamification still low, though it is interesting to be implemented. Gamification is one of the alternatives to provide enjoyment and challenging learning. The trend of gamification is similar to the previous research, which has small numbers during 2010-2014 (Qian & Clark, 2016).

5. Conclusions

Based on the main aims, the research focuses on the trends in using educational biology games from 2010 to 2019. It can be concluded that over the period the number of publications rises gradually, the use of digital games was dominant instead of the non-digital game. Further suggestion to develop educational biology game is that educators and researchers must consider the trends and types of the game. There is a significant opportunity to develop a biology game for education because the educational biology game is not many provided.

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References


Mobile Learning in Informal Science Education: A Systematic Review from 2010 to 2019

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Abstract: Over the last ten years, mobile-assisted science learning in informal context has been discussed widely in educational research community. However, the trend of applying mobile technology in informal science learning still lacks systematic analysis. In this study, a meta review of the studies published in academic journals, indexed by Scopus, from 2010 to 2019 was conducted to analyze year of publication, kind of informal learning context, and learning strategies. The results revealed that the use of mobile technologies in informal science learning have been increased in the past decade. It was also found that mostly mobile technologies have been applied in informal science learning as a learning tool. In addition, mobile learning strategies have seldom been adopted in collaborative learning, inquiry learning, and non-specified. In contrast, it was found that the number of studies using a system development has increased in recent years. Moreover, most studies reported the process of using mobile devices in context of informal science education.

Keywords: Learning technology, mobile technology, science learning, smartphone, learning context

1. Introduction

Understanding children’s interest both in the short and long-term in science is fundamentally important in educational research because interest can increase children’s motivation for learning in science (Deci, 1992). Moreover, interest can also support their willingness to participate in science related activities and jobs in the future (Ainley & Ainley, 2011). As such, supporting short-term interest (i.e., situational interest) is critical because it is the first step toward further developed, long-term interest (i.e., individual interest) in science (HiDi & Renninger, 2006). Meanwhile, informal learning settings (e.g., museums, nature centers, and zoos) are powerful venues to trigger situational interest in science (Lemke, Lecusay, Cole, & Michalchik, 2015). Learning experiences in informal settings can provide unique opportunities for the development of situational interest because informal settings offer novel and diverse resources (e.g., exhibits, specimens, and games). Relatedly, interactive resources in informal settings can create opportunities to support learner-centered interactions where people can focus on activities related to their own agenda and goals (Barron, 2006). Moreover, informal learning setting have the flexibility to adopt new kind of technologies (e.g., mobile devices, virtual reality, and augmented reality) to further facilitate the learner-centered interactions. As mobile devices, i.e. smartphones and tablets, are becoming increasingly affordable and ubiquitous in everyday life, mobile devices are used to augment learners’ interactions in informal learning spaces by enhancing novel experiences, customizing learning content, and expanding available perspectives (Charitonos, Blake, Scanlon, & Jones, 2012). The rapid development of mobile technologies offered more chances to design and develop innovative learning approach with mobile devices in preparing schools and students for a future (Panjaburee & Srisawasdi, 2018). Combining the benefit of informal settings and mobile devices, their team posits that mobile
technologies offer supplemental resources that can be leveraged to generate and develop situational interest during informal learning activities.

To date, pedagogy of mobile and ubiquitous learning has become more important in context of science education (Srisawasdi, Pondee, & Bunterm, 2018). Although there have been numerous valuable syntheses of previous studies on mobile learning in informal science education, there are areas that need further examination. For example, the study findings demonstrate that in both formal and informal learning environments, mobile gadgets, particularly smartphones and tablets, along with open source applications are efficient alternatives to mono functional at devices. There is possible for using mobile learning in the area of informal science education due to the aspects that make it unique and well fitted to features and functions of mobile technology. Nonetheless, there have been no studies of the informal learning work in school science conducted to date. In this research, literature on mobile devices informal science learning from 2010 to 2019 was reviewed for understanding the use and patterns of informal science education and mobile learning in science.

2. Literature Review

2.1 Informal Learning and Mobile Technology

Informal learning is the name given to unstructured learning that takes place, like a classroom, away from the traditional, formal learning settings. It has no clear goals or goals set, as the learner is often unplanned and self-directed. Informal training features a few hallmarks that differentiate it from more formal learning styles. The biggest is that it’s not a scheduled way to learn. This usually occurs naturally and inadvertently with the learner stumbling into a learning situation. In addition, situated mobile games allow teachers or informal educators to focus their students’ or visitors’ attention on specific aspects of the informal learning space and its exhibits or displays. Concurrently, settings on informal learning (e.g., museums, nature centers, and zoos) are important places to stimulate interest in science in circumstances (Bell, Lewenstein, Shouse, & Feder (2009). Learning in informal settings can offer unique opportunities to develop situational interest, as informal settings offer new and diverse tools (e.g., exhibits, specimens, and games). Respectively, interactive tools can create opportunities to promote learner-centered experiences in informal settings (Barron, 2006) where people can focus on their own goals and target related activities. Furthermore, informal environments often have the versatility of adopting new technologies (e.g., mobile devices, virtual reality, and augmented reality [AR]) to promote more learner-centric experiences. As mobile phones and tablets are become ever more accessible and ubiquitous in everyday life, mobile devices are used to increase interactions between learners in informal spaces by enhancing novel experiences, customizing learning content, and broadening the viewpoints available (Lyons, 2009). Informal environments and mobile devices combine advantages, their team argues that mobile technologies offer additional resources that can be leveraged during informal learning activities to create and grow situational interest. In the previous studied researcher reported that summer camp children engaged in learning on-the-move adds to the understanding of how to integrate context-sensitive technologies into informal science learning experiences. When the video data were coded to understand the types of sense-making conversations children had while using the mobile learning materials, we found the children engaged in describing, identifying, and interpreting/analysis talk related to science (Zimmerman, 2019). In addition, from the results of learning performance, stay-time, behavioral pattern analysis, and interviews, it was found that the mobile label assisted system can effectively guide visitors to interact with exhibits, conduct thoughtful learning, and prolong the visiting stay-time. Visitors are willing to visit the science museum with it (Chen, Xin, & Chen, 2017).

2.2 Mobile Learning in Science and Previous Studies

As the mobile learning area has grown and apps have developed, a range of ephemeral interpretations of mobile learning have arisen and mobile learning is a relatively new field of study, there is a lack of
studies that systematically evaluate and analyze work on mobile learning. Mobile devices were mainly for communication purposes, they found few ties to communication or cooperation study, and most studies assisted inexperienced learners. Mobile learning has a great potential to promote learning success for students in specific subjects such as science, inquiry-based learning, collaboration, communication, critical thinking, and motivation (Chang & Hwang, 2019). The ubiquity, flexibility, facility of access and diverse mobile technology capabilities make them valuable and necessary in the current times. Nevertheless, these are underused weapons in education in the science schools and, in parallel, students’ interest and engagement in science domain follow a descending trend (Bano, Zowghi, Kearney, Schuck, & Aubusson, 2018). Mobile technology and internet-access devices can help students investigate simulations online, video and virtual labs, exercises monitor and personal importance of learners (e.g., personal inquiry learning) and enhance engagement/participation in the learning process. For example, mobile devices have been successfully used in inquiry-based science learning to facilitate students into their inquiries, support formative or self-assessments and promote problem solving (Nikou, Economides, 2018). The smartphone can be a powerful device to collect data, especially with the various sensors that the modern smartphone carries; among the common built-in sensors are the accelerometer, gyroscope, magnetometer, GPS receiver, microphone and camera. In this study found that intrinsic and career motivation significant correlated with flow and enjoyment of learning experience with the AR. As such, this implied that chemistry learning activity with the use of mobile AR should consider ways to promote students’ motivation before implementing the activity (Nachairit & Srisawasdi, 2015). Furthermore, mobile technology-supported science learning is a topic under investigation. Studies on mobile learning in science education indicated that different tools/applications can be used to support science learning and that mobile devices with internet access can facilitate students’ online investigations such as simulations, video and virtual labs (Nikolopoulos & Kousloglou, 2019). The ubiquitous Geography learning system, which uses smartphone equipped with cameras and wireless communication facilities to support ubiquitous learning for Geography, is proposed. They adopt ADDIE Model in entire study, from materials analyzing, learning contents design and development, system implementation to evaluation. The use of these low-cost and popular technologies makes ubiquitous Geography learning system more available than other previously developed u-learning systems (Yang & Chang, 2017). In addition, Prasongsap & Srisawasdi (2018) reported an impact of smartphone-based inquiry laboratory on middle school students’ scientific understanding and their scientific explanation performance. The finding showed that the significant different in students’ scientific understanding was detected between pretest and posttest after their participating with smartphone-based laboratory. They expressed positive scientific explanation performance to the technology-enhanced physical science learning with smartphone-based laboratory.

Figure 1. Scopus database searching steps
3. Research Methodology

This meta-review study examined papers from Scopus database, published from 2010 to 2019, by searching for the publications whose titles, abstracts, or keywords met the prescribe logical condition. The keywords used were Mobile AND Science AND Informal AND Learning, and the selective items was article only discovered on 14\textsuperscript{th} November 2019. A total of 138 papers published were released from the database and it was an appropriate number for this study. By removing 77 non-article papers, 61 papers were comprised in the present study. By deleting 29 which were not related to mobile-based informal science learning, that is not related to student learning, papers focused on mobile-assisted informal science learning, mobile use for learning activities in science, only has been extracted in a final number of 32 articles, as show in Figure 1.

4. Research Result

4.1 Year of Publication

There were 32 papers as unit of analysis in this study. The papers were classified and reviewed by two researchers based on the coding scheme. If there were inconsistent coding results, both researchers would discuss until agreement was reached. Figure 2 demonstrates the papers on the application of mobile-assisted informal science learning from 2010 to 2019. There were no literature reviews focusing mobile-assisted informal science learning in 2010; after 2010, three papers started publishing in 2011, then decreased in 2012 with one paper which is equal to 2013. Since 2014 to 2017, academics have increased attention to this field and then continuously decreased in 2018 to 2019.

Figure 2. Published papers using mobile-assisted informal science learning from 2010 to 2019

4.2 Kind of Informal Science Learning

In this study, the researchers investigated kind of informal learning in science for each article. From the review analysis, there was a total of seven informal learning setting in science, including (i) museum, (ii) exhibition, (iii) nature center, (iv) after school, (v) community, (vi) botanical garden and (vii) non-specified. As illustrated in Figure 3, among all 32 papers, there were 20 non-specified, without specifying exact location of student’s learning activity. For more details, those studies focused on development of learning system and mobile application to promote informal science learning with mobile devices. The second place is museum which is equal to exhibition is equal to four locations; one paper adopted nature center, after school, community, and botanical garden.
4.3 Learning Strategies

The distribution of learning strategies applied in mobile-assisted informal science learning from 2010 to 2019 is indicated in Figure 4. The greatest proportion is collaborative learning, with a total of 11 papers, while the second rank is inquiry learning, with a total of 8 papers. The third rank is non-specified, with a total of three papers and the forth learning strategy are STEM and 5E, and they are equal to two paper. In addition, there are seven of each one paper such as creative skill, open learning environment, experimental learning, socio-technical system, learning-on-the move strategies, and science project.

5. Conclusion and Discussion

A meta-review analysis of using mobile-assisted informal science learning from 2010 to 2019 was performed in this study. This result indicated that the quantity of studies increased over many years and decreased in the last few years. Moreover, it was found that the number of publications which integrated mobile technology into informal science learning are greatly increased over the decades. It was also found that most of studies used learning system and mobile application development in the methodology. This implied that numerous researchers have considered to develop the application of mobile devices in science which focuses on informal learning setting. Although informal learning has become more popular due to the use of mobile technologies and devices, this reveals that more studies are required to develop learners’ scientific learning process during informal science settings. This implies that investigating effects or impacts of mobile learning approaches in context of informal science education remains an important and critical challenging question to educators and researchers.
On the other hand, it can be found that many learning strategies, for example, direct instruction, peer review, thematic debate, project-based learning, and contextual mobile learning, have hardly been implemented in mobilized science education. In the years ahead, the effectiveness of using these learning strategies with mobile technology in context of informal learning settings has been recorded in several studies; therefore, it is attempting to investigate the feasibility of applying them to science education. Exclusively, inquiry-based learning, contextual mobile learning, project-based learning, problem-based learning, peer assessment quality of critical thinking, and problem-solving could be helpful to the learners in terms of their higher-order thinking.

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References


Mobile Learning Technology in STEM Education: A Systematic Review from 2010 to 2019

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Abstract: Mobile technology could support students’ learning in anytime and anywhere. It led to mobile learning principle, which has been recognized as pedagogy to support the learning of Science, Technology, Engineering, and Mathematics (STEM). Recently, there is less systematic analysis to reveal trend of mobile learning in STEM education. This paper conducted a meta-review of the studies published in academic journals, indexed by Scopus, from 2010 to 2019 to analyze years, nationalities, and subject areas emphasizing the pedagogy and technology of mobile learning in STEM education. The results revealed that the application of mobile learning technology in STEM disciplines have been increased in the past decade. In addition, the review articles reported subject areas in social science has the highest number of using mobile technology in STEM learning. The findings of this study encourage more educational research in the area of mobile learning technology in STEM education.

Keywords: Mobile technology, ubiquitous technology, mobile learning, ubiquitous learning, STEM

1. Introduction

According to the growth of mobile technologies and expanded usage of mobile devices in education, there has been an increasing adoption of mobile learning in both formal and informal education. Mobile technologies provide new learning opportunity and enhance teaching and learning process, such as context awareness and ubiquity, personalization and adaptively, communication and collaboration among learners, interactivity and seamless bridging between contexts in both formal and informal learning. The learning tools of mobile technologies (i.e., tablets, personal digital assistants, and smartphones) are utilization of consumers, process, and store information everywhere, anytime, by anyone. Mobile learning technology is a promising in improving students’ learning outcomes, motivations and interests. Furthermore, mobile learning technology can be extended to Science, Technology, Engineering and Mathematics disciplines, which need further understanding regarding student generated multimedia activities (Yao et al. 2016; Hwang & Wu, 2014).

STEM approach derived from Science, Technology, Engineering, and Mathematics, has been the focus of educational reform in United States and the approach has been popular across the world (Susan et al., 2018). STEM approach, which has been as integrated teaching approaches, provides students with integration of science, technology, engineering, mathematics and problem-based learning. The fundamental goal of this approach is to create a leader for future that can bring a positive change on the community (Sri et al. 2019). The 21st century education has been driven by teaching and learning process regarding STEM approaches. It directly provides students with direct practice in integrating all aspects of learning, leading them to easily learn knowledge of concepts in authentic problems. Furthermore, the students use technology through science learning to operate the scientific experiment
and prove scientific law or concepts. All findings support the data management by mathematical reasoning (Bybee, 2010).

Besides, technology competency is an important skill that should be developed as one of 21st century skills. All technology tools are involved, namely computers, MP3 player, notebooks, mobile telephone, and tablets. Focuses of this mobile learning are on students with their interaction with portable technology. The use of technology motivates active learning of student, exploration, inquiry based learning, collaborative work among learners and teachers, and creativity (Robert, 2008). This study conducted a literature search of mobile learning in STEM research journals and the articles published from 2010 to 2019. The review study is operated as following aspects. First, the literature reviews were used to present the rationale for a mobile learning for STEM. Then, the research methodology section follows with the inclusion and exclusion criteria, search years, nationalities, and subject areas. Study results with limitations come afterwards. Finally, there is the conclusions section that summarizes the information of the study.

2. Review Literature

2.1 Mobile Learning

The rapid development of mobile technologies offered more chances to design and develop innovative learning approach with mobile devices in preparing schools and students for a future (Panjaburee & Srisawasdi, 2018). Mobile learning has been recognized as the approach to access education and enables learners to pursue their studies according to their own scheduled time. Mobile Learning is also free from fixed class times, which enables learning at all times and in all places, during breaks, before or after shifts, at home, or on the go because of the portability of mobile devices (Robert, 2008). Based on previous research, a broad discussion of studies on mobile and ubiquitous learning was published in six journals between 2001 and 2010. In their review of 154 articles, they discovered that the use of mobile and ubiquitous learning accelerated markedly during 2008; researchers mostly studied students in higher education, and the fields were most often researched in language arts, engineering, and computer technology (Hwang et al. 2011). Mobile learning projects revealed that most mobile learning activities occurred across the different settings, and took place within a physical context and an official environment, such as a classroom or workplace. Regarding the pedagogical roles, mobile devices play important role in education. Most researchers have used mobile devices by primarily as a sort of reinforcement tool to stimulate motivation and strengthen engagement, and secondarily as a content delivery tool. The educational projects have used mobile devices to assist with constructive thinking or reflection. Furthermore, most learning activities using mobile devices have been controlled by the teachers as well as a handful of learner center projects in existence. Concerning the communication functions, very few studies have made any use of cooperative or team communication. Moreover, the majority of studies have made the use of participants, and little research has involved experienced participants. Regarding educational goals, it was found that the majority of research has focused on lower-level knowledge and skills, and ignored higher-level tasks, such as analysis and evaluation (Dirk et al., 2009). Mobile learning facilitates the design of authentic learning, meaningful learning, where targets real world problems to make attractive learning environment to the students. Also, theoretically, the use of mobile phones in learning activities could enable students to customize the transfer of, and access to information in order to building their skills and knowledge and to meet their own educational goals. Obviously, mobile learning approach could make the student-centered learning environment and empower students to learn (Helen & Rhona, 2007).

2.2 Mobile Learning Technology in STEM Disciplines

To date, pedagogy of mobile and ubiquitous learning has become more important in context of science education (Srisawasdi, Pondee, & Bunterm, 2018). Mobile learning by using technology tools, such as mobile devices, mobile phones, tablet, laptops, or personal computers is a fairly new approach to the
educational paradigm in terms of supporting learning performance, promoting motivations to learn, and learning perceptions. Mobile learning is the process involving conversations across multiple contexts among people and personal interactive technologies (Helen & John, 2016). The implementation of STEM education can benefit the students in the fields of science, technology, engineering, and mathematics. Integrative STEM education is about the teaching and learning of one or more subject areas in schools or any other educational institution. Integrative STEM education is defined as general education focusing on preparing citizens to function in a science and technology society (Scott, 2008). STEM is the purposeful integration of various disciplines to solve real world problems involving forming all four disciplines, such as science, technology, engineering, and mathematics to one unit. Furthermore, STEM could be enhanced through the use of mobile devices (Jay et al., 2010).

3. Research Methodology

This paper started with searching publications indexed by SCOPUS database from 2010 to 2019, which have titles, abstracts, or keywords met the logical condition STEM and mobile and learning. In this study, there are 278 publications related to mobile learning and STEM. Afterward, 209 non-article papers were excluded and 69 papers were included by deleting 40 papers were not related STEM approach and mobile learning. Totally, 29 publications are the target items in this paper. The flow of information through the different phases of the review is presented in Figure 1.

Figure 1. Scopus database searching steps.

4. Research Results

4.1 Classification based on Number of Articles published by Year

There were 29 papers in this study. The articles were classified and reviewed by two authors based on the coding scheme. If there were inconsistent coding results and then the authors came to an agreement for all the differences.

Figure 2 shows the number of mobile learning for STEM articles published from 2010 to 2019, presented by the year of publication. Considering Figure 2, there were no literature reviews mobile learning for STEM articles in the years 2010 to 2012 and a period with a moderate count of mobile learning for STEM publications in the years 2012 to 2016. Afterwards, a relatively high number of mobile learning for STEM publications in the years 2017 to 2019.
4.2 Classification based on Nationalities

In this study, the articles were examined by using the nationality of the authors on mobile learning in the field of STEM area, as shown in Figure 3. There are 15 countries of nationality of authors using mobile learning to support STEM education; those are Greece, Austria, Israel, Canada, Croatia, Ireland, Italy, United Kingdom, Thailand, Indonesia, Brazil, Chile, Malaysia, Spain and United States. The results reveal that many countries have attempted to apply mobile technology in STEM teaching. Authors from United States contributed the most publications (34) relating mobile learning in STEM followed by authors from Spain (12) and Malaysia (7), Brazil and Chile with 6 authors each. Other reviews found that United States is the most contributing country regarding journal publications on mobile learning in STEM research in which STEM education has been reformed in United States (Sri et al., 2019). In addition, there are the different European countries (exception Spain), South America countries and Asia countries.

4.3 Classification based on Subject Area

The subject area were investigated in the mobile learning for STEM education, including the aspects of social sciences, computer science, engineering, biochemistry genetics and molecular biology, business management and accounting, chemistry, earth and planetary sciences, agricultural and biological sciences, immunology and microbiology, mathematics, neuroscience and physics and astronomy. Figure 4 shows the number of each subject area in the literatures. It could be seen that the studies on social sciences (18 articles), computer science (8 articles), and engineering (8 articles) constituting the majority of the research. In contrast, 13 pure science publications were related to mobile learning in STEM. It is interesting to note that the subject area related social science was the main
concern of most of the mobile learning in STEM studies among STEM education research. Many researchers intended to integrate mobile technology into STEM area because it was a motivated way to bring students’ learning with mobile devices as a learning tool.

![Subject Area](image)

**Figure 4.** Subject area on mobile learning in STEM from 2010 to 2019.

5. Conclusion and Discussion

The current study presents a review result of 29 articles related mobile learning technology in STEM education published in SCOPUS database from 2010 to 2019. This study is kind of systematic review about mobile learning for STEM area and presents the new findings that hold for the aforementioned selected journals. This result indicated that the quantity of studies increased over many years. Moreover, it was found that the number of publications which integrated the mobile technology for STEM education has been greatly increasing over the decades. It was also found that many studies used system development in the methodology. This implied that numerous researchers have considered to develop the application of mobile devices in STEM subject. In addition, United States is the most contributing country regarding journal publications on mobile learning in STEM research because STEM reform in United States. Furthermore, the issues related to social science was the majority of the mobile learning in STEM studies among STEM education research. This reveals that more studies are required to develop students’ learning performance through the process for science learning.

The study provides a synthesis of the current research and an indicator for future research in the field of mobile learning in STEM area; therefore it can be a valuable reference for educators and researchers working in this field.

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References


Mobile Technology Facilitated Physics Learning Course: A Systematic Review from 2010 to 2019

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Abstract: This paper summarizes the research on the use of mobile technology over the last ten years, where mobile learning issue in physics education have been discussed. However, there is less study revealing the trend of applying mobile technologies for teaching/learning physics regarding systematic analysis. In this study, a meta review of the studies published in academic journals indexed by SCOPUS ranging from 2010 to 2019 was conducted to analyze years of published paper, and learning strategies. The results revealed that the use of mobile technologies in physics education have been increased in the past decade. It was also found that mostly mobile technologies have been applied in scientific experiment for physics learning as a learning tool. In addition, mobile learning strategies have seldom been adopted in inquiry learning, research and development, blended learning, collaborative and STEM. In contrast, it was found that the number of studies using a system development has been increasing in recent years.

Keywords: Mobile technology, mobile learning, mobile device, physics learning, physics application

1. Introduction

The rapid development of mobile technologies offered more chances to design and develop innovative learning approach with mobile devices in preparing schools and students for a future (Panjaburee & Srisawasdi, 2018). Currently, mobile gadgets have been getting a famous era in our life. In educational system, these devices supplied educators with the opportunity to convert teaching and gaining knowledge for addressing twenty-first century learning settings. This transformed instruction creates a greater flexible learning versions that give blessings to college students who could get admission to multiple records assets and shifted from an authority-based totally mastering shape to a structure primarily based upon the idea of a network of learners (Hamm et al., 1955). It also gives educators the capability to connect with learners in many ways with devices that they use on a regular basis (Ward et al., 2013). Recently, with the advancement of technologies, more and more mobile devices have been served as technological tools for supporting learners to learn in science classrooms. These devices, including laptops, tablet PC, and smartphones, have been developed rapidly to provide better computing efficiency and mobility, and have grown in popularity as learning devices since 2002 (Lim, 2011). That is to say, the challenge is the introduction of a learning-based solution for achieving goals and choosing the right mobile technologies, as well as developing a complex technology-based environment to support and enhance the learning process. There is general agreement that mobile learning facilitates the access to education, besides, some characteristics of mobile learning can contribute to change the way in which we teach or learn. An important feature of mobile learning is that one of its goals, different from those of a traditional transfer of knowledge from teacher to student, is to empower students to actively participate in the construction of their own learning (Pena-Bandalario, 2007). Also, mobile learning can facilitate designs of authentic learning by targeting problems of interest to the learner.
(Traxler, 2007), as well as ease lifelong learning by supporting learning that occurs during the many activities of everyday life (Sharples, Taylor, & Vavoula, 2005). In teaching context, teacher involvement occupies a fundamental position of mobile learning in formal education settings (Prieto et al., 2014). For physics learning, physics mobile learning (PML) is a learning medium, and it is used as a new learning strategy and provides an interesting transformation experience (Shaheen, 2010). PML process can support higher-order learning performance through students’ participation in the use of technology, especially using mobile learning in critical thinking processes, and facilitates the students’ information with reference to the difficulty of physics material in the school room (Mcfarlane, 2013). Moreover, it enables students to learning with their lifestyle and allows them in obtaining better knowledge in terms of language and subculture, in particular in improving their potential of diagram-based representation and critical questioning (Chiang, & Lee, 2016).

2. Review Literature

2.1. Physics Learning and Previous Studies

Physics is one branch of science that is classified as the most fundamental physical knowledge and it is related to the basic principles of the universe (Serway & Jewett, 2004). Experience or direct observation with the five senses makes it easy for students to learn. These experiences will develop the ability of students gradually to understand abstract concepts of Physics, think logically, and even make generalizations (Mundilarto, 2002). Getting to know Physics must facilitate students to construct their expertise and thinking talents (Gedgrave, 2009). However, the physics learning process is still centered by the teacher’s role (Rusnayati & Prima, 2011). Teachers were not creative enough and had few experience in developing learning media basing on specific instructional goals in terms of various kinds of and attractive materials for students (Mardiana & Kuswanto, 2017), and most teachers only inform how to solve physics problems by using existing equations (Suryani, Harahap, & Sinulingga, 2017). Therefore, the physics teaching in today class is needed to be transform into more motivated and supportive way to learn by active involvement with the support of today’s technology.

The concept of physics is physical know-how, that is students’ gaining knowledge may be supported with the help of the media. Teachers, laboratory equipment, textbooks, scholar worksheets might not enough to attain the skills and learning preferences of each student. Computer and electronic generation could contain college students in various styles of science gaining knowledge, assist them to process facts, and develop cognitive skills in an extra individual manner than conventional teaching and learning models. Technology media can also help college students visualize summary standards and standards of physics. Other studies suggests that using smartphones could enhance learners' patience in learning, and enable them to have interaction in content advent and communication (Collete & Chiappetta, 1994). By using social media (Goksu & Atici, 2013). Applications on smartphones enable students to more actively discussing content with classmates and teachers, as well as allowing them to collaborate learning (Hamdani, 2013). Media in the form of smartphone applications could also improve students' scientific characters, such as curious, creative, and conscientious characteristics (Fatima & Mufti, 2014). Science learning is one of the characteristics of higher-order thinking skills. The results of previous research showed that smartphones are proven to provide students the opportunity to be active learner in learning activities.

2.2. Mobile Learning in Science and Previous Study

To date, pedagogy of mobile and ubiquitous learning has become more important in context of science education (Srisawasdi, Ponddee, & Bunterm, 2018). Mobile learning provides possibilities for students to learn wherever and whenever, supports the learning process of Physics. It has been recognized as an efficient learning medium and facilitates conveyance of the materials or tools. Previous studies have found that mobile technology is able to support the involvement of students in creative, collaborative, critical, and communicative learning activities (Alhadi & Saputra, 2016). Mobile technology offers
great affordances to support science learning (Crompton et al., 2017). With the capability to store a significant quantity of getting to know content (e.g., eBooks, videos, and audios) on a single device, mobile technology makes it less difficult for college kids to access statistics and manage academic resources. A growing wide variety of science education apps permit college students to conduct technology experiments, record data, and manipulate science simulations (Zydney & Warner, 2014). Internet-connected mobile devices also enable anytime and anywhere teacher-student and student-student interaction and communication. Teachers can use mobile devices to provide timely feedback to students, and students can use their mobile devices for self-directed remedial learning (Zhai, Zhang, & Li, 2018). Nonetheless, mobile technology research in science education has found inconsistent effect sizes on student achievement. A recent meta-analysis by that examined 27 mobile technology studies in science learning reported effect sizes ranging from .392 to .738 (Sung, Chang, & Liu, 2016). However, it was found a negative effect. Researchers call for innovative technology-integrated learning to make it possible to adopt new and arguably better approaches to instruction and/or change the content or context of learning. (Lawless & Pellegrino, 2007). Currently, mobile learning has a great potential to promote learning success for students in specific subjects such as science, inquiry-based learning, collaboration, communication, critical thinking, and motivation (Chang & Hwang, 2019). Studies on mobile learning in science education indicated that different tools/applications could be used to support science learning and that mobile devices with internet access could facilitate students’ online investigations, such as simulations, video, and virtual labs (Nikolopouloul & Kousloglou, 2019).

3. Research Methodology

This resource of research study examined papers from SCOPUS database ranging from 2010 to 2019 by searching for the publications whose titles, abstracts, or keywords met the logical conditions. Such that, key words as “mobile” AND “physics” AND “learning” were used to select the items that are article on 12th November 2019. A total of 265 publications were found for this study. By removing 47 nonrelated-article papers, 36 papers were comprised in the present study related to mobile technology in physics learning course research. 47 non-related mobile technology in physics learning were excluded. Those are related to Computational thinking 25 papers, Biology 3 papers, Machine 4 papers, Environments 3 papers, Robots 3 papers, Chemistry 1 paper, Vehicle 1 paper, Mathematics 1 paper, Medical 1 paper, Neuropsychiatric 1 paper, Estimate human 1 paper, Schizophrenia 1 paper, Microwave circuits 1 paper, Physiological Measurement 1 paper, as display in Figure 1.

**Figure 1.** Scopus database searching steps.
4. Research Result

4.1. Years of Publication

There were 36 papers in this study. The papers were classified and reviewed by two researchers based on the coding scheme. If there were inconsistent coding results, we would discuss until agreement was reached. Those do not use abbreviations in the title or heads unless they are unavoidable. Figure 2 displays the papers on the application of mobile-based physics learning from 2010 to 2019. There were no literature reviews mobile-based physics learning in 2010, after 2010, one paper started published in 2013, then increased in 2014 with two papers and four papers in 2015, then decreased in 2016 to 2017. Academics attention to this field had increased in 2018 to 2019.

![Figure 2. Years of published paper using mobile technology in Physics Learning Course from 2010 to 2019](image)

4.2. Learning Strategies

The distribution of learning strategies applied in mobile-based physics learning from 2010 to 2019 is indicated in Figure 3. The greatest proportion is inquiry-based learning approach, with a total of 18 papers, while the second are research and development, blended learning and collaborative learning with each four papers. The third greatest is project-based learning, with a total of three papers. The forth learning strategy is problem-based learning with a total of two papers. Also, the fifth is STEM with a total of one paper.

![Figure 3. Learning strategies](image)
5. Conclusion and Discussion

A meta-review and analysis of using mobile technology in physics learning from 2010 to 2019 were performed in this study. The results in this study indicated that the quantity of studies increased over many years. Moreover, it was found that the number of publications which integrated the mobile technology in physics learning are greatly increased over the decades. It was also found that many studies used newly system development in the learning activities. This implied that numerous researchers have considered to develop the application of mobile devices in science by focusing on mobile technology in physics learning. In addition, mobile learning strategies have been less adopted in inquiry-based learning, research- and development-based learning, blended learning, collaborative learning, and STEM. In contrast, it was found that the number of studies using a newly system development has increased in recent years.

Acknowledgements

This research was financially supported by Graduated School, Science Education program Faculty of Education Khon Kaen University, Thailand. I would like to thank all members of Frontiers of Educational Science and Technology (FEST) Research Network, Thailand for their academic supports and inspiration about technology-enhanced learning in science.

References


Blended Learning Supported Chemistry Course: A Systematic Review from 2010 to 2019

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Abstract: The implementation of blended learning in chemistry is rapidly growing over the past decades. However, trends and issues in the application of blended learning in chemistry are still lacking systematic reviews. This study conducted a meta-review to analyze issues related to blended chemistry learning and then present the issues of learning strategies and specific chemistry course obtained from studies published in academic journals, indexed by Scopus database in the last decade, 2010-2019. This report offers a unique contribution in terms of visualizing the trend of blended learning in chemistry. The results revealed that the implementation of blended learning in chemistry courses has increased over the past ten years. Moreover, it was also found that most pedagogic design in blended chemistry learning is problem-based learning. In terms of subject, general chemistry is the most often taught with blended learning.

Keywords: Blended learning, hybrid learning, flipped learning, chemical education, chemistry learning

1. Introduction

It is an undeniable fact that the rapid growth of technology in this modern era has significantly influenced many aspects of human life as well as education. In context of education, technology might offer easy and quick access to unlimited learning resources. The rapid development of digital technologies offered more chances to design and develop innovative learning approach with mobile devices in preparing schools and students for a future (Panjaburee & Srisawasdi, 2018). With the technological affordances, students can access and learn any learning materials from anywhere and anytime they want and by anyone. It is not a new thing to find teachers make use of technology to deliver the materials during the teaching and learning process, or the other way around, students explore the material that they are now learning from the internet to enrich their understanding about it. The integration of technology in the education process has inspired many education experts to propose innovation in the teaching and learning process, one of which is blended learning.

In 21\textsuperscript{st} century education, pedagogies of digital learning has become more important in context of science education (Srisawasdi, Pondee, & Bunterm, 2018). The development of blended learning has brought a transformation to education in all subjects. Particularly, applying blended learning in a chemistry course is an interesting issue. Many studies revealed that blended learning can be one of the effective ways to foster the quality of chemical education. For instance, blended learning supports a shift in students’ conceptual understanding of the rate of chemical reaction topic significantly more than the traditional learning (Olakanmi, 2016). Additionally, blended learning can also increase students’ outcomes significantly (Bernard, Broš, & Migdal-Mikuli, 2017). Although there have been many studies that disclose the implementation of blended learning, there are some areas that still must be discovered further. For example, distribution of blended learning in chemistry course, specific chemistry course that might be taught with the support of blended learning, and learning strategies that could support blended learning, particularly in the chemistry classroom. These issues can be used as
references for educators and researchers who want to apply blended learning, especially in chemistry class. Since there are no studies that reveal these issues yet. This paper reports literature analysis of blended learning in chemistry to better understand its implementation and trends.

2. Literature Review

Blended Learning

Blended learning is a model of learning that represents an opportunity to integrate online instruction which offers innovative and technological advances with the traditional instruction which offers direct interaction and participation (Thorne, 2004). In broader sense to Thorne (2004)’s idea, Bersin (2004) described that blended learning is a model that integrates different training “media”, such as technologies, activities, and types of events to create an effective training program for a specific audience. Meanwhile, Watson (2008) explained that blended learning is the integration of face-to-face learning and online learning to facilitate improve the classroom experience and extend learning through the innovative use of information and communications technology. Moreover, Graham (2006) described that blended learning is combining face-to-face instruction with computer-mediated instruction. At the simplest definition, blended learning is a combination of online-mediated and face-to-face instruction (Reay, 2001; Rooney, 2003; Sands, 2002; Ward & La Branche, 2003; Young, 2002). Blended learning is used interchangeably in research literature as “personalized learning”, “differentiated instruction”, “hybrid learning”, “technology-mediated instruction”, “web-enhanced instruction”, or “mixed-mode instruction” (Krasulia, 2015). To clarify the blended learning, there are four major models i.e. rotation model, flex model, self-blend model, and enriched-virtual model (Staker & Horn, 2012). Furthermore, the rotation model has four sub-models; station-rotation, lab-rotation, flipped-classroom, and individual-rotation, and the most popular model is the flipped-classroom.

Previous Studies about Blended Learning in Chemistry

There have been numerous published studies of implementation blended learning in chemistry. For instance, blended learning was implemented in an organic chemistry course (Lo & Tang, 2018). The result indicated that blended learning intervention can promote students’ advanced knowledge of synthetic tools. Besides, blended learning was also applied in the chemistry laboratory to optimize students’ experience (Kennepohl, 2013). Moreover, blended learning was also implemented in chemical information or cheminformatics course (Baykoucheva, Houck, & White, 2015). The finding revealed that students learned how to find literature and chemical property efficiently. Meanwhile, another study implemented blended learning in chemistry pharmaceutical analysis (Visentin, Ermondi, Vallaro, Scallet, & Caron, 2013). It was found that blended learning can enhance students’ involvement. Niroj & Srisawasdi (2014) developed a blended learning environment in Chemistry for enhancing students’ conceptual understanding. The study of Jihad et al. (2018) also revealed that blended learning can foster students’ conceptual understanding. Based on the literature review, an enhancing number of researchers who are struggling to implement blended learning to foster students’ learning, provided educators information to prepare learning activities appropriate for their students. To empower the research and development of chemistry education to become more enlightened, the previous implementation of blended learning has become important to analyze for better understanding in pedagogical development.

3. Research Methodology

Resource

This research study investigated published papers obtained from Scopus database from 2010 to 2019 by searching for the publications whose titles, abstracts, or keyword met the logical condition
("blended" or "hybrid" or "flipped") and ("learning") and ("chemistry"). A total of 430 papers published in the Scopus-indexed journals were appropriate for this study. By removing 138 non-article papers and 4 non-English papers, 76 papers were comprised in the present study by deleting 209 non-related papers and 3 non-available papers. Figure 1 displays the whole steps of searching.

![Diagram of searching steps](image)

**Figure 1.** Scopus database searching steps.

**Data Distribution**

Based on the analysis of searching results, Figure 2 illustrates the papers on the application of blended learning in chemistry from 2010 to 2019. There were no more than five papers were published each year from 2010 to 2014, and the average number was 2.2 papers in the first five years. Even in 2012, there was no research contribution regarding blended learning in chemistry into the literature. Since 2015, researchers paid more attention to this field, with more than 10 papers were published every year, and the average number was 13 in the last five years. In addition, there were 13 papers published in 2015. In 2016, 10 papers were published and then increased remarkably to reach the highest publication number of 16 papers in 2017. After peaking at 16 papers, these numbers of publications had fallen to 11 papers in 2018. The number of publications dramatic growth in 2019, with a total of 15 papers.

![Distribution chart](image)

**Figure 2.** Published paper using blended learning in Chemistry from 2010 to 2019.

**Coding Scheme**

In the present meta-review study, the categories being analyzed included learning strategies and chemistry courses. Each dimension is explained in the following item:
Learning strategies: According to the search results, this study classified the learning strategies into 11 categories as follows: problem-based learning, cooperative learning, collaborative learning, laboratory learning, inquiry-based learning, active learning, TSOI (translating, sculpting, operationalizing, integrating), self-regulated learning, example-based learning, comparative learning, non-specified approach.

Courses: The course examined in blended learning in chemistry were also analyzed. It is categorized into 10 different courses in the chemistry field as follows: general chemistry, organic chemistry, analytical chemistry, physical chemistry, inorganic chemistry, cheminformatics, pharmaceutical chemistry, biochemistry, forensic chemistry, pharmaceutical polymer material.

4. Results

Learning Strategies

The trend of learning strategies implemented in blended learning in chemistry from 2010 to 2019 is illustrated in Figure 3. The highest proportion is non-specified. It means that many papers did not obviously mention the specific learning strategy. Furthermore, the second-order is problem-based learning (18 papers). Many studies used problem-based learning as learning strategies in applied blended learning with any various methods and approaches. For instance, there is a study that uses a newsworthy story in teaching chemistry (Hibbard, 2019), and Weaver and Sturtevant (2015) applied problem-based learning in the context of Student-Centered Active Learning Environment with the Upside-down Pedagogies (SCALE-UP) approach. The strategy of cooperative learning is in the third rank with 15 papers in total, which is used such as interactive discussion, group discussion, team-based learning. In the analysis, it is followed by collaborative learning, with 11 total papers. Collaborative learning which is used, in this study, such as peer-led team. Laboratory learning is in the fifth rank, with 10 total papers. The sixth rank is inquiry-based learning, and there are five papers. Furthermore, active learning is in the seventh rank, with four total papers. Additionally, TSOI, self-regulated learning, example-based learning, and comparative learning are in the last place, with one paper for each.

Courses

The specific course in chemistry was investigated in the study. Figure 4 indicates that the top course of chemistry in blended learning is general chemistry (39 papers). Most studies (e.g. Mcdowell et al., 2019; Burchett et al., 2016; Enneking et al., 2019) chose general chemistry as the main subject area to apply blended learning in their classroom. The second rank is organic chemistry (24 papers). A number of organic chemistry classes (e.g. Ealy, 2013; Casselman, 2019) studies applied blended learning in their classroom. Analytical chemistry is in the third rank with four papers, followed by physical chemistry, with a total of three papers. The other courses, such as inorganic chemistry and cheminformatics,
contributed two papers for both. Furthermore, pharmaceutical chemistry, biochemistry, forensic chemistry, pharmaceutical polymer material merely contributed one paper for each.

![Image showing specific courses of blended learning in Chemistry](Figure 4)  

**Figure 4.** Specific courses of blended learning in Chemistry.

### 5. Conclusion

This present study performed a meta-review and analysis of implementing blended learning in chemistry from 2010 to 2019. The finding revealed that the implementation of blended learning in chemistry has been continuously increased over the last decade. It implies that researchers paid more and more attention to this field. Meanwhile, the finding also revealed that most studies implemented problem-based learning as learning strategies in blended learning. Nevertheless, many other learning strategies implemented in blended learning in the chemistry classroom, such as cooperative learning, collaborative learning, laboratory learning, inquiry-based learning, active learning, TSOI (Translating, Sculpting, Operationalizing, Integrating), self-regulated learning, example-based learning, and comparative learning. It implies that educators implemented blended learning in chemistry using many various learning strategies. Characteristics of the courses and learners become a consideration to select the appropriate learning strategies. Moreover, general chemistry became the most favorite course to practice blended learning. However, many other courses in chemistry implemented blended learning such as organic chemistry, analytical chemistry, physical chemistry, cheminformatics, pharmaceutical chemistry, biochemistry. It implies that blended learning can implement in several chemistry courses.

### Acknowledgments

This work was financially supported by Graduated School, Science Education program, Faculty of Education Khon Kaen University, Thailand. I would like to thank all members of Frontiers of Educational Science and Technology (FEST) Research Network, Thailand for their academic supports and inspiration about technology-enhanced learning in science.

### References


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A Review of Past Studies: Connecting Google Classroom Learning Activities with Digital & Information Literacy Linked to Bloom’s Taxonomy of Educational Objectives

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Abstract: This study reports a review of past studies focusing on measuring the effectiveness of online learning activities conducted using the Google Classroom platform in achieving learning objectives. Past studies have provided useful and practical information on the effectiveness and user satisfaction of using Google Classroom. This study extends the understanding on the applicability of the use of Google Classroom as a platform for teaching and learning. Past studies were reviewed assessing the extent activities conducted via Google Classroom in achieving digital literacy linked to Bloom’s Taxonomy of Educational Objectives in the context of science, technology, engineering and mathematics (STEM) and non-STEM learning. The achievement of STEM literacy through the learning activities on Google Classroom poses significant findings by reflecting on Bloom’s Taxonomy of Educational Objectives. This study informs stakeholders in education industry on the practical applications and areas for improvement in promoting the uptake intentions of e-learning among the educators; achieving the aspiration of Education 4.0.

Keywords: Google Classroom, learning activities, STEM, Bloom’s Taxonomy of Educational Objectives

1. Introduction

According to Bloem et al. (2014), the world is currently at the beginning point of the fourth stage of industrial development - Industrial Revolution 4.0, characterized by the so-called "Cyber-Physical Systems" (CPS). As a consequence of the ever-changing characteristics of technology, online spaces are rapidly emerging and evolving, while increasing in the overall number of users. Online spaces significantly impact how and why people learn nowadays (Gerber et al., 2016). However, as the cyber-physical world is emerging, there is a recurring issue among educators, parents and governments - concerning ways of preparing our current and future generations to thrive and succeed in this fast-changing world. Graham (2017) stated that it is beyond any doubt that education is the key of preparing our generations for the rapid development of information technology. Therefore, this paper sets out to review past studies and link the learning activities that had been carried out on a topical online learning platform, Google Classroom to Bloom’s Taxonomy of Educational Objectives in the context of science, technology, engineering and mathematics (STEM) and non-STEM learning.

1.1 Google Classroom in Education 4.0

Education 4.0 has been described as integrating technology in the context of teaching and learning (Dunwill, 2016). G Suite for Education (formerly known as Google Apps for Education) launched the free accessible Google Classroom (GC) in 2014, making it an ideal online learning platform for developing countries (Azhar & Iqbal, 2018). Since then, educators around the globe have been exploring GC for almost seven years, endeavoring for the enrichment of 21st century teaching and learning experience. Furthermore, as compared with other Learning Management Software (LMS) like Moodle,
Blackboard and Edmodo, the nature of GC as a free cloud-based learning platform - its convenience and suitability to perform mobile learning have also improved the uptake intentions of the users in recent years (Kumar & Bervell, 2019). Most educators found that GC is time-saving, easy to use and communicate with (Liu & Chuang, 2016; Martínez-Monés et al. 2017), due to its interface which incorporates many other useful Google applications, such as Google Documents, Google Slides and Google Calendar. Salmon (2019) mentioned that learners who experience Education 4.0 will wish to be equipped with skills to face the challenges of their future careers and new world of work. Therefore, it is extremely necessary for educators to use platforms like GC, to fulfill the aspirations of Education 4.0.

1.2 Digital and Information Literacy Linked to Bloom’s Taxonomy of Educational Objectives

Educational technologies have been developed from learning theories, combined with the design of digital learning activities (Beetham, 2013). The learning outcomes, on the other hand, can be interpreted in different levels of attainment and grades, such as through Bloom et al. (1956). The association between learning outcomes with relevant taxonomies provides the ability to independently evaluate the outcomes concerning knowledge, abilities and values (Beetham, 2013). In this context, these distinctions provide a valuable check on designing online learning activities, by assessing their educational objectives and level of learning experience. A certain level of digital and information literacy will be needed in achieving the goals of the online learning activities. There are six levels of educational objectives in Bloom’s revised taxonomy with their respective cognitive processes work with knowledge – remember, understand, apply, analyze, evaluate and create. The six categories of objectives were arranged in a cumulative hierarchy; as achieving the next more complex skill or ability involves the prior achievement (Anderson et al., 2001). For more detailed information on the original and the revised Bloom’s Taxonomy, the study by Krathwohl (2001) can be referred.

1.3 Reflecting STEM Literacy through Bloom’s Taxonomy of Educational Objectives

Nowadays, science, technology, engineering and mathematics (STEM) learning has a wider definition to take in environment, economics, and medicine (Zollman, 2012). As we are in the generation that STEM literacy is required to become productive and knowledgeable citizens; however, there is no particular agreement in education that define STEM literacy (Zollman, 2012). According to the previous researcher, STEM literacy should not be viewed as a content field but should be as an integrative means, consisting of skills, abilities, factual information, procedures, concepts and metacognitive capacities to gain further learning. It has also been clarified by Zollman (2012) that Bloom’s Taxonomy of Educational Objectives (1956) is a better approach in reflecting the synergy of strands in STEM literacy. Fisher (2009) also proposed a renewed interest in Bloom’s Taxonomy – Bloom’s Digital Taxonomy, which advances an extension on students’ access to knowledge on online learning platforms. It is undeniable that the need to evolve from learning for STEM literacy to using STEM literacy for digital learning in order to satisfy our societal, economical and personal needs is really inevitable, and it is also in line with the aim to achieve the aspirations of Education 4.0.

1.4 The Present Study

Although there are studies on the effectiveness and satisfaction on GC in enhancing online learning experiences among the students, there is no comprehensive picture of how the learning activities on GC can be connected to the achievement of educational objectives. It is vital that the educators must thoughtfully design online learning activities, in order to maximize the effectiveness of the activities and to enrich the online learning experience of the learners. Therefore, this study provides a review of past studies by connecting the learning activities carried out on GC to the digital literacy linked to Bloom’s Taxonomy of Educational Objectives in the context of STEM and non-STEM learning.

As Cropanzano (2009) described, theory papers can be more interesting when they “underscore commonalities that build coherence” (p. 1306). By connecting the learning activities on GC to the educational objectives, this study can provide new insights on the perceived benefits and also limitations.
of GC that can be further improved in the future. It is undeniable that the uptake of online learning among educators around the globe is escalating, especially during the closedown of schools worldwide due to COVID-19 pandemic. Therefore, this study provides a better understanding of the effectiveness of GC and the perceived benefits of adopting it.

2. Method

2.1 Searching

The federated search service provided by Universiti Tunku Abdul Rahman (UTAR) was used. It includes a wide range of prominent educational and social science databases, such as ERIC, Emerald Insight and Elsevier. Besides, Google Scholar and Research Gate were also used as external resources. Snowballing method was adopted to select the relevant studies. The following terms or combinations of terms were assessed via advanced search using Boolean search technique: Title contains Google Classroom AND learning activities OR activity OR learning tasks OR task AND field contains higher education OR undergraduate OR tertiary education. The research studies selected were not restricted to Malaysian context; research studies from other countries were also taken into consideration, with the publication year from 2016 until 2020. In addition, the material type selected was articles with English as the language of the studies. As can be seen in Figure 1, in total, 229 articles were found at the initial stage.

2.2 Selection

The articles found were further selected based on these criteria: (i) the study reports on students learning; (ii) the study was conducted in higher education settings; (iii) the study provides empirical data; (iv) the study’s primary focus was on the effectiveness of GC, not only on the psychological perceptions of GC users. Therefore, the following forms of research studies were rejected: (i) meta-analyses reports; (ii) studies that did not focus on students learning; (iii) studies conducted in primary and secondary school settings (iv) studies which focused only on the psychological perceptions of the GC users. In addition, after excluding materials such as unpublished theses and conference papers, a total of seven articles were selected for review.

2.3 Analysis

Based on the hierarchy of Bloom’s taxonomy, the learning activities included in the studies reviewed have been classified into six categories - remember, understand, apply, analyze, evaluate and create. The contents of the selected articles were analyzed and summarized. The analysis includes the subject involved (STEM-related or non-STEM-related), research design, major findings of the research and the linking of learning activities to Bloom’s Taxonomy of Educational Objectives.

3. Results

It has been found that almost all of the selected studies involved GC learning activities require the skills and ability to analyze and evaluate among the learners (See Table 1). As the skills in Bloom’s Taxonomy are arranged in a cumulative hierarchy (Anderson et al., 2001); achieving the skills of analyzing and evaluating involves the prior achievement of skills of remembering, understanding and applying. The ability to analyze and evaluate. The ability to analyze and evaluate are mostly required for the completion of learning activities such as reviewing information, answering questionnaires and tests that had been assigned on GC, carrying out online discussion, giving feedback by posting directly to the flow of discussions, creating mind maps through Google Draw, reflecting upon own learning through
GC’s questioning capabilities, reacting to remarks, tracking and viewing their own progress in the learner’s portal and performing collaborative learning and peer tutoring. On the other hand, the skill and ability to create had been required for learning activities such as sharing of materials and contribute to resources through Google Slides, making certain illustrations on certain topics and doing individual or group projects.

Search for key terms and combinations of terms via advanced search using Boolean search technique: Title contains *Google Classroom* AND *learning activities* OR *activity* OR *learning tasks* OR *task* AND field contains *higher education* OR *undergraduate* OR *tertiary education*

The research studies selected are not restricted to Malaysian context; research studies from other countries are also taken into consideration, with the publication year from 2016 until 2020 (229 articles were found)

Filter 229 articles by rejecting the following forms of studies:
(i) meta-analyses reports
(ii) studies that did not focus on students learning
(iii) studies conducted in primary and secondary school settings
(iv) studies which focused only on the psychological perceptions of the GC users
(v) studies which are unpublished theses and conference papers

Manual review of selected studies for further short-listing (resulting in final selection of 7 research articles)

The contents of the selected articles were analyzed and summarized. The analysis includes the subject involved, research design, major findings of the research and the linking of learning activities to Bloom’s Taxonomy of Educational Objectives.

Summarize findings into Table 1 “Summary of the Past Studies on Google Classroom and Linking of Learning Activities to Bloom’s Taxonomy of Educational Objectives”.

Discuss the findings on the effectiveness of Google Classroom, the distinctions of learning activities and cognitive requirements for STEM and non-STEM related subjects, and finally the implications and

*Figure 1. Methodological process for meta-analysis of past studies.*
<table>
<thead>
<tr>
<th>Research</th>
<th>Subject</th>
<th>Research design</th>
<th>Linking of learning activities to Bloom’s taxonomy</th>
<th>Major findings</th>
<th>Limitations and recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaharane et al. (2016), Malaysia</td>
<td>Data mining subject under the Decision Sciences programme (STEM-related)</td>
<td>Quantitative design: Questionnaire</td>
<td><strong>Analyze</strong>: Making observations, post questions&lt;br&gt;<strong>Evaluate</strong>: Examine information, review what is already known using tools (computer software) to analyze the data and interpret data</td>
<td>Overall students are satisfied with Google Classroom thus showing it is effective as an active learning tool.</td>
<td>It is recommended that Google Classroom’s tools should be integrated into the teaching and learning of data mining software. It will enhance the teaching and learning of data mining and related application.</td>
</tr>
<tr>
<td>Dash (2019), India</td>
<td>Biochemistry (STEM-related)</td>
<td>Quantitative design: Questionnaire</td>
<td><strong>Create (Evaluate, Analyze, Apply, Understand, Remember)</strong>: Make certain illustrations on the topic of acid-base balance and upload the images on Google classroom</td>
<td>Learners reported to have better access to learning material and supplementary teaching resources, helpfulness of immediate feedback, and learning outside of the class environment. Preference of mobile phone over laptop to access Google Classroom was reported. Medical schools using e-learning employ blended learning as the most common computer assisted technology, and in that regard, Google Classroom can assist in enhancing faculty effectiveness and efficiency.</td>
<td>Wider adoption of this free to use LMS is encouraged, especially in resource limited low- and middle-income countries, to encourage greater access to e-learning. Items inquiring about better access to learning material, use of additional learning resources like YouTube videos scored high indicating effectiveness of this LMS. Complex STEM (Science, Technology, Engineering, and Mathematics) subjects like biochemistry stand to benefit from such innovations.</td>
</tr>
<tr>
<td>Basher</td>
<td>Different</td>
<td>Quantitative</td>
<td><strong>Evaluate</strong> (Analyze, Apply, Understand, Remember)</td>
<td>There are significant statistical</td>
<td>Attention to train the teacher</td>
</tr>
<tr>
<td>Year</td>
<td>Country</td>
<td>Course Area</td>
<td>Study Type</td>
<td>Design</td>
<td>Pre-service &amp; During Service</td>
</tr>
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</table>
| 2017 | Saudi Arabia | Subjects for pre-service teachers (Non-STEM-related) | Experimental | Understand, Remember: Answer questionnaires and tests that had been assigned on GC  
*Unjustifiable: Publish assignments and homework on GC | Differences in the results between the experimental and controlled group when the Google classroom application applied, on teaching efficiency of educational college students in each of its levels (planning, execute and evaluation) and in academic achievement in computer. (pre-service & during service) to use computer applications in various teaching and administrative work, creation of laboratories in colleges and different educational establishments to use computers in the teaching of different subjects and to train students to use it. |
| Heggart & Yoo (2018), Australia | Pre-service teacher course (Non-STEM-related) | Quantitative | Remember: Complete readings  
Understand: Answer surveys and questionnaires through Google Forms  
Apply: Contribute to discussions  
Analyze: Create mind maps through Google Draw  
Evaluate: Reflect upon own learning through GC’s questioning capabilities  
Create: Sharing of materials and contribute to resources through Google Slides | Google Classroom increased student participation and learning and improved classroom dynamics. It also revealed concerns around pace and user experience. Google Classroom enables increased pace accessibility with the foster of collaboration agency and voice, which leads to quality learning. The use of the learning platform was generally perceived to be a positive experience, although some students did identify some concerns regarding the rapid delivery of the content, and the danger of overwhelming students through pace needs to be carefully managed. |
| Mafa (2018), South Africa | Healthcare Service Management (Non-STEM-related) | Quantitative | Evaluate (Analyze): React to remarks, track and view their own progress in the learner’s portal  
*Unjustifiable: Upload | Google Classroom is a powerful tool in instruction and learning among higher education learners. Learning and acquiring skills and knowledge through  
The researcher recommends facilitators to take advantage and utilize GC in their teaching in light of the fact that it gives a rehash of what they have said |
<table>
<thead>
<tr>
<th>Authors</th>
<th>Course</th>
<th>Design</th>
<th>Activity</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventayen et al.</td>
<td>Economics, Basic Finance (Non-STEM-related)</td>
<td>Quantitative design: Questionnaire</td>
<td><strong>Analyze (Apply, Understand, Remember):</strong> Answer quizzes, examination and assignment</td>
<td>Google Classroom is preferable over that which is acquired through in-classroom contacts. and done amid classroom addresses. Higher education institutions should give portable technology gadgets or potential mobile devices to their learners to exploit this internet inclining learning tool.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Evaluate (Analyze):</strong> Carry out discussion, collaborative learning and peer tutoring</td>
<td>Google Classroom is extremely useful due to its comprehensibility, attractiveness, and operability. Besides of its practicality in conducting non-academic activities, the platform is also convenient for group assignment and collaborative learning.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Create (Evaluate, Analyze, Apply, Understand, Remember):</strong> Do individual project and group Project</td>
<td>It is suggested that institutions who practice blended learning could utilize GC as a tool for eLearning.</td>
</tr>
<tr>
<td>Alim et al.</td>
<td>Teacher Training and Education (Non-STEM-related)</td>
<td>Qualitative design: In-depth interview</td>
<td><strong>Understand:</strong> Obtain and read timely updates related to lessons (access multimedia equipment)</td>
<td>The use of Google Classroom was effective with various limitations: (1) not all students got an account what was provided by the lecturers because they did not have a smartphone, (2) Wi-Fi availability in the campus was limited and (3) the students did not have enough mobile data plan during the time of online discussion and some students submitted their assignments using their friends’ account.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Analyze:</strong> Carry out online discussion, give feedback by posting directly to the flow of discussions</td>
<td>The study will allow future initiatives to take into consideration the issues and challenges related to accessibility, connectivity and affordability among the users of the platform, in this case the students.</td>
</tr>
</tbody>
</table>

*Note:* justification cannot be made on the requirement of skills based on the learning activities mentioned.
4. Discussion

The review of the selected past studies found that there are indeed significant achievements of Bloom’s Taxonomy of Educational Objectives aligned with the learning activities carried out using GC. In addition, educators and researchers (Alim et al., 2019; Dash, 2019; Ventayen et al. 2018) also view GC as an extremely effective Learning Management System (LMS). Multiple benefits have been reported by adopting GC in conducting e-learning; such as empowering teachers to post class materials, permitting the formation of private classes and groups so that there are no interlopers to unapproved groups or classes; learners allowed to upload documents and assignments anytime to the online platform; and constant collaboration among the learners, in which they can share their thoughts online (Basher, 2017; Mafa, 2018).

In addition, Basher (2017) highlighted that the learners should be encouraged to self-evaluate and develop skills in using the Internet; enhance their information and digital literacy, in order to be efficient in their respective fields.

4.1 STEM related Subjects

The selected studies which were conducted in the context of STEM-related subjects, which are Biochemistry (Dash, 2019) and data mining (Shaharanee et al., 2016) are found to involve learning activities which required more complex cognitive abilities i.e. create and evaluate. In the data mining subject, the learners were required to examine information and review what is already known using computer software tools to analyze and interpret the data. On the other hand, the biochemistry subject required the learners to perform skill and ability to create, which also involved the ability to evaluate, analyze, apply, understand, remember, in order to make certain illustrations on the topic of acid–base balance. Moreover, it has been suggested by Dash (2019) that items inquiring about better access to learning materials, use of additional learning resources like YouTube videos scored high indicating effectiveness of GC. Consequently, complex STEM subjects like biochemistry stand to benefit from such innovations.

4.2 Non-STEM related Subjects

In contrary, there are five selected studies which have been conducted in the context of non-STEM-related subjects, which are teachers training and education-related subjects (Alim et al., 2019; Basher, 2017; Heggart & Yoo, 2018), healthcare service management (Mafa, 2018), and lastly economics and basic finance (Ventayen et al., 2018). It has been found that the skills of remembering, understanding, applying, analyzing, evaluating and creating are all involved in different learning activities for the non-STEM-related subjects. The learners were given the tasks to reflect on their own progress of learning, besides tracking and reacting to the feedback that they have received, in which the ability of evaluating was predominantly required in almost all of the studies. The analyzing skill was also needed for most of the learning activities that involves the answering of tests, questionnaires, quizzes and contributing to discussions. Non-STEM-related subjects, which are mostly related to the field of social science and management also stand to benefit from the practicality of GC in conducting non-academic activities. As suggested by Ventayen et al. (2018), GC encourages the peer tutoring and collaborative learning among the learners.

4.3 Implications

Meanwhile, in the context of learner’s perspective, if skills, concepts and values do not interconnect in the intended outcomes, learners may not consider that particular educational technology as an integral part of their learning experience (Beetham, 2013). Therefore, educators should consider whether the online learning platform is conducive in supporting a wide range of learning objectives as they design the activities. Thence, the digital and information literacy linked to Bloom’s taxonomy of educational objectives is to support the creation of practical learning outcomes while including the digital capabilities and approaches. As Zollman (2012) stated, STEM literacy in education ought to be projected in enhancing
the learning for economic, societal and personal needs, the students have to develop from “learning to know and do” to “learning to live together and to be” (p.15). By reflecting the achievement of Bloom’s Taxonomy of Educational Objectives on Google Classroom learning activities, STEM literacy which promotes integration of skills and collaborative learning thus can be accessed in the era of Education 4.0. By this, the use of online learning platforms like Google Classroom can be more prevalent among the educators in the future.

5. Conclusion

To conclude, this paper critically reviewed the related literature by assessing the achievements of educational objectives aligned with the learning activities carried out using GC. The findings on the inclusion of different levels of cognitive abilities through the learning activities on Google Classroom will be able to help improve the use of online learning platforms for STEM and also non-STEM disciplines in the future. As a result, the stakeholders in the education industry will be able to grab a comprehensive picture of what is working well and what is in need of improvements to further promote e-learning, thus boosting the uptake intentions of e-learning among the educators; achieving the aspiration of Education 4.0.

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References


Assessing UPM Initiative in Future Proofing Graduates through Innovative Physical Learning Environment

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Abstract: The aim of this paper is to study the effects of the fourth industrial revolution (I.R.4.0) on the learning methods and the physical learning environment. This paper reviews multiple theories of designing innovative future learning spaces to create a clear definition of the characteristics of a physical future learning environment. After creating a list of the required characteristics of a future learning environment, a visual observation is done to compare this list to the characteristics of the current innovative future learning spaces (Putra Future Classroom) in Universiti Putra Malaysia (UPM). This paper is written based on an ongoing study that aims to present an understanding on the strengths and the issues in the current design of the Putra Future Classroom. The findings of this paper could help create design guidelines for Universiti Putra Malaysia and other Malaysian universities to design a better innovative learning spaces that is designed to respond to the future changes in students’ needs and learning methods. This study can contribute in improving the quality of higher education in Malaysia and the learning experience of the students and creating better prepared future proof graduates.

Keywords: Education 4.0, future learning, future classroom, personalization, learning experience

1. Introduction

In the past years, we have witnessed a revolutionary use of the internet and digitalization on our industry, business, education, and everyday life. This occurrence is referred to as Industrial Revolution 4.0, or I.R.4.0, which is defined as the evolution of cyber-system production and digital transformation (Shahroom & Hussin, 2018).

Like any aspect, education has been significantly affected by I.R.4.0 and the Internet of Things (IOT). The use of internet and digitalization, the technological evolution, the increasing demand for non-traditional learning and the increasing opportunities for professionally-oriented jobs which according to Keser & Semerci (2019) required students to have higher social skills and problem solving abilities has led to creating new teaching and learning methods which further led to the need to improve the physical learning spaces to serve these methods (Wagner & Wallner, 2016). Furthermore, this transition has also changed the way students receive the information and to seek freedom and control over the learning process which cannot be achieved through traditional learning models and spaces. The increasing diversity of students’ nature and background due to the decrease of manual job opportunities which led to a higher number of people with different age, culture and backgrounds to seek higher education (Altbach, P. G., Reisberg, L. and Rumbley, 2018). This diversity has already created a gap between the students’ needs and what the traditional learning models can offer, and this is where the nontraditional learning becomes essential.
2. Learning models in Education 4.0

Most communities in the era of I.R.4.0 are now moving toward interculturality and flexibility. This is what causes fresh graduates to face struggles when trying to find their place (Glasby, 2015). To help with that, learning models in Education 4.0 should offer flexibility and freedom which can help support the needs of the students. According to Redecker et al. (2016), a successful and supportive learning system should focus on personalization, collaboration and informalization. This can also help students to face their issues, develop better social skills and further engage in society.

Several learning methods have been created in response to that. These methods can be used alone or they can be merged together based on the content and the needs of the students. Collaborative and Group Learning has been widely used as they can help the students to share knowledge and develop social skills (Boruvkova & Emanovsky, 2016). Crossover Learning and Experience or Project-Based Learning have the ability to enrich the learning process with self-teaching through tasks, projects and experience to gain knowledge (Andresen, Boud, & Cohen, 2016). Computer Assisted Learning offers a variety of display which improves the content delivery process through computer programs and multimedia (Holt et al., 2016). Online Learning or distant learning offers learning from anywhere in the world which gives opportunities for many people with physical distance issue (Stern, 2014). The popularity of this type of learning has increased significantly all over the world in 2020 due to the lockdown, it allowed students to attend classes while practicing social distancing. And lastly, Immersive Learning which gives the students the ability to immerse in the learning content and experience any environment through simulated or virtual environment (Shang Ly, Saadé & Morin, 2017).

3. Physical learning environment in relation to Education 4.0 learning models

Several theories have discussed the characteristics of a learning environment that has the ability to support the existing learning models and are flexible enough to adapt to future developments in learning and teaching.

All the theories are related in proposing a flexible design solution on the same concern. However, each of the theories analyses the issue from a different aspect. Theory 1 by Duvivier (2019) concentrates on the relation between formal learning and casual daily activities due to the increased usage of the internet and online learning and how the design of the learning environment should respond accordingly. Theory 2 by McDaniel (2012) described the increasing variety of students’ backgrounds based on the changing market demands and the need for a flexible learning strategies and environment to cater these needs. The first two theories focused on the design of the learning environment in general and how to design informal spaces to serve the learning needs. However, Theory 3 by Kim, (2019) focuses specifically on the physical design of the classroom or the lecture room to provide students comfort, maintain their health and enhance their thinking. And finally, Theory 4 by Niemi, (2018) discusses the effects of new technologies on the learning environment and the need to create a flexible learning space that can adapt to the rapidly changing technologies.

3.1 Theory 1: Impact of technology on facilities by Robbert J. Duvivier (2019)

According to Duvivier (2019), today’s learning tend to happen in more informal spaces than the actual classroom as long as these spaces provide comfort and an internet access, this means that every space in campus (corridors, lounges, cafes and etc.) can be designed to serve as a learning space. Students today find comfort and encouragement in places that offer a combination of food or drink services and a good wireless network with the working environment, that is why modern café are the first place to consider going to for both students and professionals (Brown, 2018). The increasing reliance of the students on the internet and
technologies in their daily life has led to a higher interaction between the physical and virtual world, this has also led to more interaction between the learning environment and the learning activities (Brown, 2018).

Considering these changes creates a need to redesign the physical learning environment in universities and higher education institutions to offer students the ability to merge the learning process and individual or group work with their daily living activities such as drinking and relaxing. This can be achieved through designing casual multi-purpose spaces that offer internet connection with a variety of services, technologies, and furniture settings that can provide comfort and serve the needs of every student (Duvivier, 2019).


With the increasing variety of students’ age and backgrounds, a range of formal and informal learning options should be offered by the universities to support everyone’s needs. This is where these universities need to create a variety of flexible formal and informal learning spaces that can support these learning options. Because no matter how popular virtual and online learning becomes, a physical interaction in the learning process is still very important to the modern student (McDaniel, 2014). However, the new technologies has changed the style of learning from passive lecturer-led to active informal collaborative and self-led learning (Shah, 2013). Learning spaces design should consider these changes in the learning styles to offer a flexible, adaptive and personalized learning experience (Brown, 2018).

A flexible learning space should offer multiple types of furniture with different purposes, tables and chairs of different types and sizes, and a pantry area for the basic food or beverage services and other settings that can improve the students comfort (McDaniel, 2014). According to (Shah, 2013) most students are encouraged to spend time in spaces that offer them a sense of control. This can be achieved through using flexible space settings that the students can control and change according to their needs.

Direct contact between the formal (classroom) and informal spaces (courtyards or lounges) can also help students to relax and take breaks from the learning process. Both formal and informal spaces should provide a variety of display technologies, electrical ports and internet connection to encourage group work. A flexible learning space should also provide movable chairs and round or modular tables, working surfaces (white boards, chalk boards, screens and etc), storage areas and space dividers that can be used to divide the space into smaller individual or group work areas (McDaniel, 2014).

3.3 Theory 3: Flipped classroom by Andrew Kim, (2019)

A flipped classroom is an active and personalized space that contains a variety of flexible cluster furniture and round tables with multiple sizes. This type of setting gives the students the ability to work individually and in groups, it also allows the lecturer to move freely around the space for better interaction with the students (Kim, 2019). Flipped classrooms also contains relaxing lounge style corners that the students can use to take breaks and change the posture when needed. Natural indoor green elements and large windows with nature views are proven by studies to trigger the students’ critical thinking (Kim, 2019). Screens and display surfaces are an important element in the design, along with movable working surfaces for easier knowledge sharing between the students (Jamilah, Yusof, Bakar, & Salim, 2018) (figure 1).

As the internet and technologies become a part of our everyday life, our ways of learning have also changed significantly and will continue to change with the constant development of these technologies. And with this change, the need to rethink the design of the learning spaces to adapt to the new needs became essential. Learning spaces today should be designed to be flexible and adaptive, containing multi-purpose spaces with multi-use digital and physical services. The space should be designed to support collaborative and group learning along with individual self-led learning (Niemi, 2018).

Larger spaces can use multi-levels that can used as seating areas as well as to divide the space into smaller spaces with different purposes. Various types of movable and flexible furniture, working surfaces, display surfaces, electric ports and a strong internet connection are all essential elements in the design (Niemi, 2018). Having break spaces is also very important for both students and lecturers, these spaces can be designed as lounges with pantry services for rest and refreshing (Niemi, 2018).

3.5 Comparison of theories

The method of creating the checklist was selected to create a clear set of characteristics that are agreed upon by different researchers with different specialties and points of view. Visual observation was done to achieve the main aim of this research, which is to evaluate the physical elements of a future learning space in Putra Future Classroom, find the strengths and the weaknesses and give recommendations for further design enhancement accordingly.

The original research, however, uses a questionnaire survey for the students using Putra Future Classroom to create a deeper insight on the satisfaction and the needs of Malaysian students in public universities in Malaysia. Interviews are also conducted with PFC lecturers, Design team and management in order to create a better understanding of the different needs and issues in designing spaces like PFC. The findings from the different methodologies are used to achieve the main objective of the original research: to give recommendations on designing the future learning facilities that can improve higher education quality in UPM which can furthermore provide guidelines for local universities to improve learning conditions and preparing graduates with better set of skills and knowledge.
By comparing the characteristics mentioned in theory 1 (Impact of technology on facilities by Robbert J. Duvivier (2019)), theory 2 (Informal learning spaces by Stephanie McDaniel, AIA, LEED AP BD + C, (2014)), theory 3 (Flipped classroom by Andrew Kim, (2019)) and theory 4 (Future learning environments Campus retrofitting by Niemi, (2018)) and taking only the elements that were shared by two or more theories (table 1).

Table 1. Comparison of theories

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Theory 1</th>
<th>Theory 2</th>
<th>Theory 3</th>
<th>Theory 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong internet access 24/7</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Combining living activities with learning</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Designing the spaces to be multi-use</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Chalkboards, white boards and other working surfaces</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Merging screens, interactive surfaces and other learning technologies into the space</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Access to electric ports</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Direct connection between formal and informal gathering and learning spaces</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>variety of flexible and comfortable furniture</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Access to pantry area</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Movable dividing walls and shelves</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>small private spaces for individual work</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Spaces for group work</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Various sizes of movable round tables and chairs</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Multi-level spaces</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Soft floor carpet and acoustic ceiling to create a good acoustic environment.</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

By taking only the elements that were shared by two or more theories (table 1), the final list of characteristics is defined as:

- Strong internet access 24/7
- Combining living activities with learning
- Designing the spaces to be multi-use
- Merging screens, interactive surfaces and other learning technologies into the space
- Chalkboards, white boards and other working surfaces
- Merging screens, interactive surfaces and other learning technologies into the space
- Access to electric ports
- Direct connection between formal and informal gathering and learning spaces
- variety of flexible and comfortable furniture
- Access to pantry area
- Movable dividing walls and shelves
- small private spaces for individual work
- Spaces for group work
- Various sizes of movable round tables and chairs
4. The characteristics of a future learning environment in Putra Future Classroom (PFC)

After creating a detailed checklist of the characteristics of innovative learning environment, a visual observation was conducted in PFC during class time to compare the checklist to the characteristics and physical elements provided in PFC.

The observation showed that the internet connection in PFC is considerably poor (650-1500 kbps/s) and covers less than 60% of faculty spaces. However, the connection process is easy and fast with no login required. A close pantry area is provided near the classroom with limited access to faculty staff. Food is neither provided nor allowed in the classroom. However, drinks are allowed and a vending machine for drinks and beverages is provided near the classroom (figure 2).

![Vending machine outside of PFC.](image)

The classroom provides good resting furniture. A comfortable sofa corner with thick cushion is provided that offers back support, neck support, arm support and pillows (figure 3). The chairs used in the classroom are also comfortable with cushions, back support, arm support but with no neck support. The furniture is highly flexible and easily movable. Modular tables are used with the ability to connect them to create a larger table or separate them for individual use (figure 4). However, space dividers and storage spaces are unavailable and therefore discussion corners and individual quite corners are also unavailable.
Heating and cooling systems are controlled by IOT. Which gives limited control for the students over the power and the temperature. The classroom is only available for students during class time, and napping or sleeping in the classroom is not allowed.

The classroom offers a variety of technologies. Large screens, interactive surfaces and projectors are provided with unlimited access for both the lecturer and the students and a sufficient number of electrical ports (1 port per 2 students) is also provided in every corner in the classroom (figure 5). The class also provides tempered glass boards for students’ and lecturers’ use. A direct connection between the classroom and outside courtyard with sitting areas is provided for resting and refreshment (figure 6).
5. CONCLUSION

By comparing the list with the findings of the observation, it is found that PFC provides a very good physical setting, the furniture used in the classroom provides flexibility which can change the configuration of the classroom based on the content of the subject or the needs of the students. The lounge sofa and bean bag corner helps students to rest and take breaks from the chair sitting posture. The chairs used in the classroom are movable and comfortable and the modular shape of the tables makes the classroom highly flexible and adaptive to any present or future learning activity.
The technologies provided in the classroom offer a great learning and teaching experience for the students and the lecturer. The interactive 60” touch screen offers an easier media for content delivery. The number of screens used help students from every corner in the classroom to have a clear view to the screen. The smart connection system and the easy internet connection process help students to engage their personal phones or tablets in the learning process by sharing the screen with the lecturer and with other students and using the device camera to create an augmented reality. The classroom even provides a sufficient number of electrical ports which makes PFC BYOD (Bring Your Own Device) friendly, this allows students to bring their own laptops or other devices when needed.

The classroom also provides a direct connection with an informal outdoor courtyard space with sitting areas and a vending machine, this connection allows students to go outside and relax and refresh whenever they feel stressed.

However, a large category of characteristics is missing in the design of PFC. The classroom is not available for the students outside class time, and the prohibition of daily living activities (eating, taking rest naps) in the classroom prevent students from having a sense of control and ownership over the space which reduces their comfort and desire to spend more time in the classroom. The poor internet speed might cause a barrier when the learning process is in progress especially those which includes live streaming or video streaming.

In general, PFC in UPM offers a very good physical setting and technologies. However, improving these spaces can be achieved by focusing more on merging the daily living activities in the learning process and permission of usage outside the formal class time. This can be done easier when the space is designed as a “learning space” rather that a “classroom” that is open for the students and provides services that can increase the comfort of the students and their sense of control over the space.

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References


The integration of Mobile Instant Messaging to a Peer-Interaction Programming Learning System

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Abstract: Computer programming is essential knowledge in the digital age and becoming a critical subject during recent years. However, learn to program is not an easy topic, as supported by many researchers. During the development of information technology, many online learning systems have been developed and proven their positive effect on students learning. Many of them focused on helping students learn to program. However, few studies have geared toward supporting its use in programming courses with the support of instant messaging, which is extremely popular in the past few years. Therefore, this study aimed to upgrade an existed online learning system named Peer-Interaction Programming Learning System to enhance students' peer-interaction by integrating with a mobile instant messaging service. In this paper, we reported on the development of the integration and its user interface, discussed our motivation and future work.

Keywords: online learning system, programming learning, peer interaction, facebook messenger

1. Introduction

In recent years, Online Learning System has emerged as a popular innovative platform, offering equitable access to lifelong open learning opportunities (Raspopovic, Cvetanovic, Medan, & Ljubojevic, 2017). From past studies, the learning benefits of online learning systems have been well recognized (Gökçearslan & Alper, 2015). Allen and Seaman (2016) reported that 77.1% of academic leaders in America agreed that online learning is critical to their long-term strategy. Increasing numbers of institutions have offered online programming courses to accommodate students’ needs and also to reduce their budget (El Said, 2017); however, among many courses, programming courses still are the most difficult courses for many students (Dolgopolovas, Jevsikova, & Dagiene, 2018). Jenkins (2002) pointed out that the teaching methods employed by the instructor are the primary factors on student achievement during programming courses, but Matthíasdóttir (2006) discuss that the problematic nature of computer programming is the actual cause of programming difficulty. Gomes and Mendes (2007) in another research argue that some of the issues contributed to programming activity are the study methods, abilities, and attitudes employed by the student, also the nature of the art of programming, the lack of prior knowledge of novice students, and the psychological influence that the student suffered from society (Jenkins, 2002). Students lack motivation and low self-efficacy for learning and may lead to lower completion rates than in face-to-face courses (Lai, Tho, & Liang, 2017). One of the possible reason is the lack of peer interaction and less immediate feedback from the instructor (Echeverría, Cobos, Machuca, & Claros, 2017; Lu, Huang, Huang, & Yang, 2017).

Little empirical research has been conducted in remedial online programming courses with regard to peer interaction. Law, Lee, and Yu (2010) suggest that social pressure and competition have a significant and positive relationship with efficacy during their research with an online programming learning system named Programming Assignment Assessment System (PASS). For decades, researchers have been building online learning systems to lower the barrier to programming learning (Bergin & Reilly, 2005; Funabiki, Korenaga, Nakanishi, & Watanabe, 2013; Lai et al., 2017; Law et al., 2010; Matthíasdóttir, 2006; Thomas, Ratcliffe, Woodbury, & Jarman, 2002). For example, Peer-Interaction Programming Learning System (PIPLS) is an online learning system based on a Question Generated strategy created by Lai and Tho (2016). PIPLS have a significant effect in support students learn to program by using the Question Generated
strategy and allow students to have some peer-interactions features such as comment and voting (Lai et al., 2017). However, the web-based online learning system still has difficulty with engaging students to interact with each other. Although their research helps improve students’ achievement in programming courses, more empirical research is necessary for peer-interaction settings due to the explosion of social networks nowadays.

On the other hand, the popularity of smartphones leads to the widespread use of text messaging and mobile instant messaging (Tang & Hew, 2017) in recent years. However, many researchers integrated messaging tools in higher education teaching and learning but limited only to the exchange of text-based messages or PC-based tools (So, 2016). Teachers may not be comfortable when integrating mobile technologies into their teaching (So, 2016) and may not realize the potential of mobile instant messaging in create alternative spaces for student peer-interaction engagement (Rambe & Bere, 2013).

2. Mobile Instant Messaging in education

In the past decade, Mobile Instant Messaging (MIM) has become extremely popular (So, 2016). Tang and Hew (2017) in their recent research revealed six applications in which MIM was used in education included journaling, dialogic, transmissive, constructionist with peer feedback, helpline, and assessment. Among them, the three most common are dialogic (Almekhlafy & Alzubi, 2016; A. Lai, 2016; Ng, Luk, & Lam, 2016; So, 2016; Willemsen, 2015), transmissive (Chai & Fan, 2016; Gutierrez-Colon Plana, Gimeno, Appel, & Hopkins, 2015), and helpline purposes (Hazaea & Alzubi, 2016; Zhang & Xue, 2015). However, among various types of MIM applications, most of the previous researchers only using MIM as a forum with notification send to student’s mobile phones, and have the group size depends on the number of students. Because of this, there are some negative effects of MIM were reported such as too much irrelevant information (Hazaea & Alzubi, 2016; Tang & Hew, 2017) or too much interference with learners’ private lives (So, 2016; Tang & Hew, 2017). This way of use MIM in education also makes some instructors did not feel comfortable using their private phone number or private account because they felt that work and private life should be kept separate (Khatoon, Hill, & Walmsley, 2015; Tang & Hew, 2017).

One key reason for MIM’s negative effects is the educator often use MIM to create a chatroom between students in their class; all the messages will be sent to all students without any filter. Students then can only accept the message or “mute” the conversation or even “leave” the group. There is no easy-use mechanism to help the educator to manage messages when they integrate normal MIM applications into their classes such as WhatsApp or WeChat.

Facebook announced chatbots for the Facebook Messenger Platform in April 2016. This brings up an idea to fix the afore-mentioned MIM negative effects in teaching and learning by using a chatbot to manage and redirect messages in MIM during educational activities.

Therefore, this study aimed to fulfill the gaps which remain in previous research by design a chatbot that can be integrated into an existed programming learning system named Peer-Interaction Programming Learning System (PIPLS).

3. Description of the PIPLS

PIPLS is an online programming learning system first developed in 2015 in National DongHwa University, Taiwan, with the primary aim to assisting beginners in learning programming with the Student Question Generation (SQG) strategy (Lai & Tho, 2016). It is now regularly used as an integrated part of many undergraduate courses related to computer programming.

PIPLS allows students to choose to use their real name, their nickname or anonymous in their posts included questions, comments, and all other activities. PIPLS supports student-generated multiple types of questions, included free-response, multiple-choices, fill in the blanks, and true-false questions. In this system, the students can discuss with each other by asking a question, answer, or comment on another’s
questions. The teachers can set questions, share the resources of learning, and develop the effectiveness of class management.

After logging in, via the home page (Fig. 1), students can find some quick statistical information about their progress: courses they are following, contributed questions, answered questions, unanswered questions, and exercises with the grade.

![PIPLS Main Page](image)

*Figure 1. The main page of PIPLS*

In PIPLS, answers are revealed according to the course setting. The teacher can allow the student to view others’ answers by default, after the deadline or only after the student submitted the correct answer for automatically judged questions or the answer for an essay question.

According to peer-interaction features, students also have the opportunity to write formative feedback to the question author, thanks to the comment feature of original Question2Answer which is visible to all users and can agree or disagree with other feedback provided by their peers by voting feature. When the others’ answer is visible, students can comment and also vote in others’ answer.

PIPLS automatically generate feedback for students who answer multiple-choice, true/false, fill in the blanks, and coding questions, by reporting whether the answer is correct (by percentage) or not. In the PIPLS, we have two types of free-response questions: essay questions and coding questions. Essay questions need an author or teacher to examine, but other types of questions are automatically judged. PIPLS is now supporting C, C++, Java, Pascal, Python, JavaScript, and PHP in the auto-judge function. For coding questions, all feedback returned by the compiler will be converted as a comment from “The Judge” user, so students can feel more comfortable while interacting with the system.

Coding questions are not only judged automatically, but the teacher also can re-judge the answer in case the compiler cannot or if the teacher wants to give some bonus points for the excellent solution.

4. The integration of Mobile Instant Messaging

To avoid the previous problems of MIM negative effects, we did not create any group chat but create a Facebook Page named PIPLS with its bot. All the notifications in PIPLS will be sent to students by Facebook Messenger, students also able to post a question to a discussion board or reply to another’s comment or send a private message by communicating with Facebook Messenger Bot. This solution also can solve many of MIM’s negative effects such as students can control by themselves which topic they want to subscribe to or not, and more critical, both their identity and their private life is fully protected.

4.1 Register and subscribe
Firstly, the student needs to register with the bot their identity as shown in Fig. 2. This mechanism can help the bot identity the student, then used this information to redirect the notification to the student.

4.2 MIM enhanced features

By implementing a chatbot to PIPLS, we can use all possible applications of MIM in education such as journaling, dialogic, transmissive, constructionist with peer feedback, helpline, and assessment. Due to the limit of this paper, only the use of the Discussion board is described next.

Whenever one student or teacher posts a question to the Discussion board, all students in the class can receive the question and the detailed link (Figure 3). The student can have three options: Reply, Follow, or Unfollow the discussion. The unfollow option will be selected automatically to prevent students to receive too much un-necessary notification.

![Figure 6. Register and subscribe to PIPLS](image)

![Figure 7. Students receive notification and can comment to a question](image)
Not only text can be posted during the conversation but also multimedia content. Students also can use the web interface to interact with the system as shown in Figure. 4.

![Web interface of commenting to a discussion](image)

**Figure 8.** The web interface of commenting to a discussion

5. Conclusion and future work

We developed a new approach to MIM integration to a system based on previous research and focused on supporting students to learn Programming. We also extended the ability of MIM using in the education environment and erased some of the MIM negative effects which happen during the previous studies. We hope to give more support to students when compared with other systems which also support programming learning and/or integrated with MIM.

In the future, we will plan to enhance the existed systems’ functions and evaluate the impact of the tool on students’ performance. We also intend to study the nature and quality of the contents produced by students.
References


Risk of Learning Discontinuity for Learning in Unfamiliar Outdoor Environments
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Abstract: Outdoor spaces often have positive connotations for its ability to enhance learning. However, there is a chance that this learning environment unable to provide the expected learning outcomes. This paper explores whether and to what extent the practice of learning in this environment is consistent or conflicting with John Dewey’s concept of continuity of experience. Critical reflection was made on two residential outdoor environmental education courses to observe how residential outdoor learning environments courses are exposed to the risk of learning discontinuity. As a result, the study reveals that there is in fact a risk of learning discontinuity when the learning that take place in outdoor environments adopt a threefold relationship between unfamiliarity, contrast and spatial movement. The implication of this paper is the suggestion to find a way to connect and reconnect the learning environments involved in learning.

Keywords: learning environment, outdoor learning, environmental education, experiential learning

1. Introduction

Learning environments nowadays are not limited to traditional classrooms. Learning environments can be out-of-door, online, formal, non-formal or informal and many more. According to Cleveland (2009), the term ‘learning environment’ also embeds the concept of social, psychological and conceptual environment. Although the study conducted by Barksdale et al, (2019) indicates that there was no association between the environment of the classroom and students’ achievement in mathematics and reading, other studies provide contrary evidence. Learning environment is an important variable in learning. It can either decide what types of activities can be done, how students perceive their learning experience, and what the learning outcomes are (Ellis & Goodyear, 2016).

Similarly, in the studies on environmental education, which is the context in which this study centre around, the general consensus is that learning environments do have an influence on learning achievement. In particular, studies suggest that the environment in the outdoor learning space is ideal for learning about the environment and sustainable development. For example, according to Harrison (2010), learning in nature could encourage people to commit to environmental activism through experiential engagement in nature. These researchers further argue that through deep, immersive practices people might learn to understand better the detrimental impact that humans have in their relationship with nature. The suggestion is that knowledge learned from such experiences is developed through affective engagement that develops very specifically from the interactions between those people with that place (Christie & Higgins, 2012).

Consequently, transformative learning environment and other related topics such as place-based learning have emerged in the practice and research in the field of education. The initiatives to transform learning environments in former studies focused on one or more aspects of the environment that were suggested by Cleveland (2009). Subsequently, various scales for evaluating and guiding the development of learning environments have been developed. For example, Yang and Huang (2015) developed a scale for evaluating technology-rich classrooms. Before that, Classroom Environment Scale (CES) (Moos & Trickett,1987) and Science Learning Environment Inventory (LEI) (Anderson & Walberg, 1974) Laboratory Environment Inventory (SLEI) (Fraser et al., 1993) have long been used in the studies of the related area.

Out of the existing scales, one aspect related to the learning environment was found was not addressed. The aspect is regarding the risk of learning discontinuity for learning implemented in unfamiliar...
environments. In the next section, this paper presents the theoretical framework that explains the importance of learning continuity from the perspective of John Dewey’s concept of continuity learning experience. This then followed by the explanation on the outdoor learning environments used for learning about the environment and sustainable development. Based on these two bodies of literature, the question this paper aims to answer is: How residential outdoor learning environments used for learning about the environment and sustainable development are exposed to the risk of learning discontinuity?

2. Continuity of Learning Experience

John Dewey’s (1953) concept of continuity of experience is a central philosophical pillar to describe the importance of learning continuity. In his book Experience and Education, Dewey (1938, p. 35) explains that “the principle of continuity of experience means that every experience both takes up something from those which have gone before and modifies in some way the quality of those which come after”. As such, learning should connect experiences in the past, present, and future.

Growth is the example Dewey provides to explain the principle of continuity of experience. According to Dewey (1938, p. 38), “every experience is a moving force. Its value can be judged only on the ground of what it moves toward and into”. As an experience grows, the direction it takes could either promote or impede further growth. Moreover, if it promotes growth, the experience could be educative. However, he also states that experiences can be miseducative where they lead to disconnected and dispersive outcomes (Dewey, 1938). In addition, the direction depends on the manner an experience “arouses curiosity, strengthens initiative, and sets up desires and purposes that are sufficiently intense” (Dewey, 1938, p. 38) to resonate and reveal the further direction of the experience’s growth (Dewey, 1938). In other words, growth of an experience controls the connections between experiences. Thus, observing the growth of an experience and the connections it forms would provide indications which discriminate between experiences that are educationally worthwhile from those that are not.

A specific circumstance may be required to enable an experience to be educative. The ways people perceive the significance of an experience and process it have some bearing on whether the experience may be deemed as promoting or impeding growth and educative or miseducative. Dewey (1938) proposes that this requires attitudes that value the personal, emotional, and intellectual growth of oneself and others. As such, for this to happen, people are encouraged to see beyond taken-for-granted assumptions, to look for doubt amongst certainty, and develop critically-informed problem-solving modes of enquiry. He described a process by which this might come about (Dewey, 1938, p. 69): (i) observation of surrounding conditions; (ii) knowledge of what has happened in similar situations in the past, a knowledge obtained partly by recollection and partly from the information, advice, and warning of those who have had a wider experience; and, (iii) judgment which puts together what is observed and what is recalled to see what they signify.

Perhaps because it requires judgement with a certain level of intellect and emotion, Dewey (1938) suggests that maturity is needed to enable a person to go through the process of forming a continuity of disintegrated experiences. For this reason, he recommends that adults assist younger people in reorganising connections between experiences in pursuing growth of these experiences. Furthermore, according to Dewey (1938, p. 38), “the greater maturity of experience which should belong to the adult as educator puts him (sic) in a position to evaluate each experience of the young in a way in which the one having the less mature experience cannot do”.

Other authors have built on Deweyian thinking. According to Miettinen (2000), continuity of experience occurs in situations where uncertainty and indetermination emerge and the normal course of forming a connection between activities is disturbed, resulting in an impediment to the connection’s normal flow. This process requires observation of surrounding conditions. The observation would reveal if disturbance exists and whether efforts to solve the problem are required or not (Miettinen, 2000). If disturbance exists between an individual and surrounding conditions, Miettinen (2000) argues that intellectualisation and reasoning is required to study the conditions causing the problem before the working hypothesis to solve the problem is proposed and tested using overt action or imaginative action. When this
happens, the intellectual outcomes of the process could be used as a resource for emergent problems and moreover, all these processes may reoccur and require constant attention and problem solving (Miettinen, 2000). While the latter part of Miettinen’s (2000) explanation reflects Dewey’s idea that connecting experiences requires some effort to make judgement, the earlier part on disturbance is rather different. Miettinen (2000) seems confident that connecting experiences that appear disintegrated will also lead to the sort of growth that Dewey is concerned with.

Based on the above discussion on continuity of learning experience, it is noteworthy that in order to choose or design a learning environment, it is important to consider its ability to provide learning continuity. It is to ensure that the learning environment can promote instead of hinder learning.

3. Residential Outdoor Learning Environments for learning about the environment and sustainable development

Residential outdoor learning environments refer to non-formal residential outdoor learning settings where participants spend nights away from their homes. In Malaysia, this learning environment is commonly used but not limited for camping. The lodging can be in different forms, for example dormitory, cabin and chalet.

The definition of residential outdoor learning environment was derived from the description of the fourth zone of a concentric circle of outdoor learning (Figure 1.1) that Beames, Higgins and Nicol (2012) proposed. According to these researchers, characteristics of the fourth zone may involve some logistical challenges such as “transportation, accommodation, equipment, food and instruction” (p.6), which are usually managed by the learning organizer or residential provider (Beames et al., 2012). This model is helpful because it demonstrates how residential outdoor learning environment is geographically remote from the everyday location of learners’ schools and homes.

![Concentric circles of outdoor learning](image)

*Figure 1. Concentric circles of outdoor learning (Beames, Higgins & Nicol, 2012).*

The model helps to show the potential for geographical progression whereby outdoor learning may start within the range of the school grounds (Zone 1) before the students are taken out further into the local neighbourhood (Zone 2), day excursions or field trips (Zone 3), and then further away from home and overnight (Zone 4) (Beames et al., 2012).

As mentioned previously in this paper, residential outdoor learning environments are commonly used to educate people about the environment and sustainable development with many government agencies and non-government organisations (NGOs) using this learning environment for supplementing environmental education in the formal curriculum, in collaboration with schools across the country. To conduct learning in this environment, the learning often organised in close proximity to so-called natural
settings such as jungles, beaches, islands and mountainous regions (Asirvatham, 2009). The aim is to educate the students and teach them about the natural environment and its conservation (Asirvatham, 2009; Bhandari & Abe, 2000). In many cases, students who participate in learning in this environment are transferred from where they live to a residential setting deemed to be closer to nature. For example, learners are transported from a different type of terrain (i.e. mountainous) to wetlands. It would appear, therefore, that the contrast between where participants normally live and their temporary relocation to an ROEE centre might create a degree of unfamiliarity between the ecological settings, although they are generally still in the same climate (Othman, Harun, Muda & Ismail, 2013). This threefold relationship between unfamiliarity, contrast and spatial movement are key to this investigation. Investigating learnings that take place at residential outdoor learning environments, therefore, presents an interesting empirical opportunity.

4. Methodology

This study was conducted using a qualitative exploratory research design. Specifically, the study used critical reflection as a method of inquiry to answer the research questions. Reflection, or being reflective, refers to an in-depth consideration of events or situations by the researchers, for example, by reliving and re-rendering who said and did what, how, when, where, and why (Bolton, 2009). The approach adopted to conduct the critical reflection through the lens of constructivist and experiential approach of learning that have allowed the researcher to recognize and acknowledge that there are multiple social realities. Also, these approaches allow knowledge to be created through a process of interpretation of research data by the researcher (Charmaz, 2014).

The study emerged from the researcher’s experience when the researcher was invited to observe two Malaysian ROEE courses that were organized by a city council in collaboration with a local environmental NGO. Both of the ROEE courses involved participants from urban industrial areas. The first course brought 40 primary school students to a coastal residential outdoor centre, while the second course was for 40 secondary school students and took place at a residential outdoor centre in jungle. The reason for selecting the participants from the two schools to attend the free ROEE courses emerged from the organiser’s concerns about what they called ‘the serious issue of open burning and waste management in the residential area of the participants’.

Sandercock (2000) suggests four phases for conducting critical analysis: identifying; analysing; connecting; and applying. More specifically, the process should consist of “identifying the issues that may influence the research design; analysing the role and impact these issues may have on the research design; connecting these issues with research design and applying the result of this reflection process to the research design focusing on the selection and deployment of research tools and techniques,” (Clarke & Turner, 2002, p. 2-3). The current study adapted this suggestion. The researcher did not exactly follow the four phases – in term of the phase fractions and their order. However the overall process of critical reflection did consist of them all. By adapting this suggestion, critical reflection was made through participatory observation and through analysis of photos that were taken during the two ROEE courses. Participatory observation of the courses gave the researcher insights into the types of teaching practices adopted in ROEE courses and how these compared to theories related to environmental learning. Photos analysis was helpful to help the researcher to recall the details of the courses. The photos used are mostly shows the activities conducted with the participants and also the view of the location where the activities took place.

Research data were analysed thematically. Both deductive and inductive methods of data analysis were used to enrich the findings. The deductive data analysis was conducted during the analysis process by comparing data with philosophical and theoretical assumption. The former refers to the way the researcher views the world and how he/she obtain and use knowledge as theoretical lens (Trauth, 2001). The latter reflects potential theory/theories that could influence the way the research is conducted or certain objects perceived (Clarke & Turner, 2002). In particular, in this study, the researcher primarily compared the practice of the ROEE courses with literature on and related to the concept of continuity of learning experience that was presented earlier in this paper.
As the study critically reflected the researcher’s own experience, reflexivity was an important to ensure that this research was conducted in a genuinely reflexive manner. Therefore, the researcher attempted to be reflexive at every stage of the study.

5. Findings and Discussion

5.1 Unfamiliarity, Contrast and Spatial Movement

Based on the description on the sample of study, it is noteworthy that there is a contrast between where participants normally live and the location where the ROEE took place. While the participants are from urban industrial areas, the learning environments were in close proximity to nature. Their temporary relocation to an ROEE centre therefore, might create a degree of unfamiliarity between the ecological settings. Although they are generally still in the same climate (Othman et al., 2013), the courses are most likely would neither support continuity of experience nor promote appropriate growth in learning as Dewey (1938) suggested.

As mentioned previously, the observed ROEE courses took place at a coastal residential centre and in the jungle. In fact, it is a common practice where ROEE courses in Malaysia are usually organised in close proximity to so-called natural settings such as jungles, beaches, islands and mountainous regions (Asirvatham, 2009). The purpose is to educate the students and teach them about the natural environment and its conservation (Asirvatham, 2009; Bhandari & Abe, 2000). It could be argued that deep, immersive experiences could lead to greater environmental awareness and activism. However, the ROEE courses presented a real paradox. On the one hand the organisers were promoting the notion of transferable learning by telling the students that their experiences on these ROEE courses would have a direct relevance to their home lives; and on the other hand they appeared to be relying on the power of the experience itself to make the difference and not their own pedagogical practices.

This was evidenced when during the introductions for both courses, the organisers explained that the reason for selecting the participants to attend the free ROEE courses. As mentioned earlier, it was due to the organiser’s concerns about what they called ‘the serious issue of open burning and waste management in the residential area of the participants’. The introductions also included statistical data that compared the number of cases of these practices in that area with other areas. However, by the end of the course the researcher was struck by the fact that only one learning activity was directly relevant to the environmental issues addressed in the introduction to the courses (the participants were taught how to recycle papers on their own). The other activities were primarily about marine/rainforest ecology, which is different from the participants’ daily context.

While Dewey (1938) suggests that it is crucial to make connections between experiences in the past, present, and future, the difference between the contexts involved in the transfer could vary substantially. For Priest and Gass (2005), an unfamiliar environment may represent clear differences that learners need to comprehend if transfer is to be successful.

5.2 Transfer of Learning

The primary school participants were 11 years old, while the secondary school participants were 16 years old. Therefore, transfer of learning could be very challenging, especially given that the age of the participants at the time. As stated by Dewey (1938), it requires judgement with a certain level of intellect and emotion to connect a learning experience to other related experiences. Hence, he suggests that maturity is needed to enable a person to go through the process of forming a continuity of disintegrated experiences.

According to Brown (2010, p. 17), “attempts to transfer skills/knowledge from previous situations in fact hinders rather than aids performance”. This critique is based on a particular standpoint which identifies psychology literature as too narrowly defined to embrace the complexity of all social systems that interact and combine to impact on learners’ environments (Billett, 1996; Brown, 2010). The danger of this
position is that educators end up adopting an uncritical stance including taken-for-granted assumptions that knowledge and skills can be isolated and removed from their original context and then applied as general or abstract principles in other situations (Brown, 2010; Lobato, 2006).

Whilst the process of generalisation and abstraction could make the transfer of learning possible, Billett (1996) points out that the less relevance there is between the original context and that of its application, the more difficult the transfer is likely to be. For Brown (2010) transfer is mostly likely to happen if situations involved in it are very familiar. Furthermore, Beames and Brown (2016, p. 51) argue that learning something with a higher degree of relatedness to “settings, contents, methods and learning outcomes” in everyday settings is important in helping students to engage with real-world issues.

Recent work on authenticity by Beames and Brown (2016) provide support for the above arguments because the residential settings are far removed from participants’ daily surroundings. They suggest that educational encounters based on unfamiliar, contrasting, and spatially specific approaches, such as the model adopted by ROEE in Malaysia, may result in learning that is less effective. According to Beames and Brown (2016, p. 51), “authenticity in education is concerned with learning that takes place in the real world and which can be usefully applied in everyday life”. The suggestion is that more effort is required to bridge the settings, content, methods, and learning outcomes with participants’ everyday life contexts.

5.3 The need of follow-up interventions

While their venue had already made the researcher question the ability of ROEE courses to encourage actions after the programme ended, another question rose was how ROEE organizers would know if their courses had been successful when the intended actions would take place after the programme had ended. The ROEE courses were one-off. The researcher was alert to the fact that the organizers and/or teachers were supposed to supplement the environmental education that took place in the formal curriculum. However, through an informal conversation with the organizers indicated that no such connections were being made. In addition, the organizers informed that post-learning assessment had never been part of their undertakings in the courses. In addition, teachers usually only involve in the courses as a gatekeeper for the organizers to get access to school participants and also by accompanying participants during the courses. It is uncertain whether the teachers provide follow-up at school, but based on the observation made, the teachers somehow were inattentive during the courses. They rarely participate in any activities.

Dillon et al. (2006) and Uzzell et al. (1995) suggest that an effective follow-up after outdoor experiences is necessary to reinforce learning. According to Uzell et al. (1995), the follow-up should help and enable the participants to make clear links between the outdoor and indoor activities. This link is important because one of the common problems that hinders the effectiveness of an outdoor education course is the transfer of the knowledge that is acquired from the course into a different context or social environment (Brown, 2010). For the same reason, Kendall and Roger (2015) suggest that residential experiences should be more integrated with school-based learning that takes place before and after the trip away. However, the critical reflection of this study supports the claim made by Lobato (2006). Frequently no effort is made to show how such knowledge is potentially influenced by the social processes in a new context, especially when the knowledge acquired is decontextualized and viewed as separate from the situations in which it was developed.

Follow-up learning experiences should not necessarily use the same outdoor learning approaches as the ROEE course. For example, the follow-up activities could be in the form of learning in a classroom, or through an assessment. Howell (2012) and Mair and Laing (2013) propose a number of intervention activities that can be used to promote environmental behavior change, which could also be used as follow-up activities for ROEE. In reference to the cocentric circle in Figure 1, it is suggested that the follow-up courses use school grounds or local neighbourhoods as sites for learning. The key point here is that a more coherent pedagogical approach is required to integrate the zones of learning outlined in Beames et al. (2012). Otherwise, if one were not provided with follow-up work to reinforce learning, he/she should make an effort to seek to interact with the people who possess a certain knowledge and qualities, such as a positive attitude, that would encourage and facilitate his/her environmental behaviour change, which is the pragmatic learning outcomes of environmental education.
6. Conclusion

The purpose of this study was to investigate how residential outdoor learning environments courses are exposed to the risk of learning discontinuity despite being described as an ideal learning environment for learning about the environment and sustainable development. Framed by John Dewey’s concept of continuity of experience, findings and discussions of the study reveal that the practices of ROEE courses at unfamiliar outdoor environments are controversial. The ability of the courses and the learning environment to promote environmental attitude and behavior change could be very challenging. One-off, unfamiliar, contrast and spatial movement approach that were adopted in the courses are most likely would neither support continuity of experience nor promote appropriate growth in learning, which are very crucial according to the Deweyian concept of experiential learning.

However, this assumption on the ability of the ROEE courses and unfamiliar outdoor learning environments to produce the pragmatic outcome of environmental education may be wrong until it is supported by evidence from a more systematic empirical studies. However, very few study has investigated at their effectiveness. In addition, none of the studies address this gap about one-off, unfamiliar, contrast and spatial movement approach. Therefore, the current study suggests that future studies should be conducted to explore if this learning environment could promote learning continuity. In addition, data-driven monitoring and evaluation is critical for guiding, planning, and assessing if the practices have the ability to fulfil the goals set in the local and global policies on environmental education.

Nevertheless, organizers of ROEE can already begin to rethink and reconsider their strategies. For example, instead of transporting students to unfamiliar locations or learning environments, with different ecological, social and geographical environments, it may be that learning environments closer to participants’ everyday lives would be more effective. If ROEE courses are to continue with their current mandate to deliver environmental education in unfamiliar learning environments then they need to consider more seriously how participants are taught and how they can apply what they have learned in contrasting ecological, social and geographical environments. An example of this might be how learning on a marine ecology module can be applied to the context of living in an urban industrialised area. In these ways, participants are less concerned with the transfer of learning, so much as with learning about the places and communities in which they normally inhabit. Also, the organizers of ROEE should also consider planning follow-up activities for the participants. As mentioned earlier, follow-up activities can be in any form, as long as the activities can help students to reinforce what they learned at the courses, and most importantly to build continuity in their learning experience.

Acknowledgements

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References


Building creative confidence during COVID-19: adapting design thinking for online learning

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Abstract: In this paper, we describe our experience in designing and delivering a course on Creativity and Innovation Management with a heavy emphasis on Design Thinking using Kolb’s Learning Cycle theory as a framework. The main challenge involved being able to preserve targeted outcomes based on Creative Confidence despite the constraints imposed by lockdowns due to the COVID-19 pandemic. The metadisciplinary approach to re-implementing the course with technology through principles involving Puentedura’s SAMR model has yielded positive results based on creative confidence as the primary desired outcome.

Keywords: design thinking, experiential learning cycle, creative confidence, SAMR model, COVID-19, online learning

1. Introduction

Creative confidence is an important competence cultivated in students by design thinking education (Rauth et al., 2010; Jobst et al., 2012, p. 45) as well as in design thinking practice (Kelley & Kelley, 2013, pp. 69-70). By building foundational knowledge on empathizing, ideating, prototyping, and testing, design thinking methodologies contextualized as an educational model establish methods, mindsets, and processes that are crucial in reinforcing creative behavior. Glen et. al (2014) argue that design thinking education is relevant not only to design-related fields but to businesses as well. Innovations driven by design thinking may be key to creating value for the customer, competitive advantage for the business, and solutions for the organization.

In this paper, we evaluate the course DECS25 Creative Thinking and Innovation Management, a required core subject taught to all undergraduate students of the John Gokongwei School of Management at the Ateneo de Manila University in the Philippines. The course specifically aims to introduce design thinking and other creative problem-solving methods in the field of business, culminating in a capstone project where real-world problem solving for businesses is simulated. The subjects involved in this study are a total of 133 third-year students, and the course was adapted into an online learning environment using a learning management system (LMS) to address the prohibitions of face-to-face teaching during the COVID-19 pandemic.

In the study, we leverage on design thinking as a metadisciplinary framework in (1) teaching it as a core educational concept that can be translated in an online learning environment, (2) its adaptation into the course design and teaching methodology, and (3) its application as a practical tool required for the students’ output in the course. We also focus on design thinking’s ability to maintain, and arguably, augment its capacity to deliver core creative competencies through technology-aided pedagogical execution in the context of challenges brought about by the pandemic.

2. Methods

2.1 Challenges brought about by the COVID-19 pandemic
In the previous semester, the university attempted to pilot online learning for a month to bridge topics that were interrupted due to the lockdown and quarantine imposed by the Philippine government. This experience revealed several issues that became the basis of formally transitioning to online learning for the following intersession. In no particular order, these were the anticipated considerations made while designing DECSC25’s online course:

Table 1. Anticipated challenges to online learning

<table>
<thead>
<tr>
<th>A. Technology / Infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>#A1 Some students have an unstable internet connection.</td>
</tr>
<tr>
<td>#A2 Group activities are more difficult to conduct due to varying internet connection levels, personal schedules, living conditions, etc.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. Classroom Dynamics</th>
</tr>
</thead>
<tbody>
<tr>
<td>#B1 The traditional “teaching by telling” will not be as effective since students are likely to be disengaged or distracted at a certain point due to the physical absence of a teacher.</td>
</tr>
<tr>
<td>#B2 The course should be able to cater to different learning styles to be effective and engaging.</td>
</tr>
<tr>
<td>#B3 The ideal learning experience is composed of relevant content and learning from teachers and peers. This is no longer as convenient and immediate in an online setting.</td>
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</tbody>
</table>

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<thead>
<tr>
<th>C. Assessment Formats</th>
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</thead>
<tbody>
<tr>
<td>#C1 Summative assessments, previously the norm, do not provide enough feedback about what the students have learned. Formative assessments will serve this purpose better.</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>D. Workload</th>
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<tbody>
<tr>
<td>#D1 Formative assessments take more time for students to accomplish and for teachers to check.</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>E. Mode of Learning</th>
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<tbody>
<tr>
<td>#E1 Bias for asynchronous learning experiences to account for students’ varying accessibility to the internet results in students being in control of their pace. They can easily spend too little or too much time on the course without proper guidance.</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>F. Student-Teacher Communications</th>
</tr>
</thead>
<tbody>
<tr>
<td>#F1 Feedback is not as immediate as in the traditional classroom set-up, where students can consult more easily or receive answers to their questions more quickly.</td>
</tr>
<tr>
<td>#F2 There is a lack of verbal and non-verbal cues.</td>
</tr>
</tbody>
</table>

However, once the course had begun, teaching faculty were also confronted by unforeseen challenges reported through direct student feedback and discussions in the wider university community:

Table 2. Unforeseen challenges during online learning

<table>
<thead>
<tr>
<th>A. Technology / Infrastructure</th>
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<tbody>
<tr>
<td>#A3 The start of the intersession semester was impacted by technical problems during enrollment and enlistment which delayed access to the LMS for some students.</td>
</tr>
<tr>
<td>#A4 Computer screen fatigue was reported by several students as well as faculty members.</td>
</tr>
<tr>
<td>#A5 The pacing of intersession combined with the adjustment to a new LMS and teaching methods had implications on the mental health of both students and teachers.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. Classroom Dynamics</th>
</tr>
</thead>
<tbody>
<tr>
<td>#B4 Learning time to understand lessons and topics were underestimated by teachers.</td>
</tr>
<tr>
<td>#B5 The students’ capacity to independently understand topics varied in a self-paced environment.</td>
</tr>
<tr>
<td>#B6 Unfamiliarity with classmates made group dynamics harder.</td>
</tr>
<tr>
<td>#B7 Students were found to have prioritized Math-based subjects more due to the difficulty of understanding mathematical concepts independently.</td>
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<tr>
<th>C. Assessment Formats</th>
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<tbody>
<tr>
<td>#C2 The format and structure of the course’s capstone project needed to be adjusted due to the</td>
</tr>
</tbody>
</table>
inhibiting nature of the original face-to-face course being judged by a live panel.

### D. Workload
#D2 Students taking 1-2 other online courses simultaneously during intersession reported an increase in workload for assessments relative to their experience in face-to-face classes.

#D3 There was a reported tendency for teachers to increase the number of assessments to compensate for the reduced number of synchronous sessions and direct interaction.

### E. Mode of Learning
#E2 Once a week limit for synchronous sessions as imposed by the university across all courses led to an inconsistent view of the scope and content of the sessions for the students.

### F. Student-Teacher Communications
#F3 The idea that students could do the course at their own pace led them to message teachers outside of socially acceptable hours and on unofficial platforms.

### G. External Factors
#G1 Socio-economic issues, especially those on a national level, negatively impacted students’ emotional well-being, which also affected their adjustment to the online classroom setting.

#G2 Staying home due to the community quarantine blurred boundaries between the students’ personal and academic lives.

#G3 Lack of access to their usual coping mechanisms and knowledge of other stress-relieving activities led to students feeling overwhelmed.

These factors were substantiated through qualitative feedback that was formally submitted by DECSC25 students, faculty, and findings of the university community during intersession.

### 2.2 Course Design

The course was collaboratively designed by six teaching faculty members of the Ateneo who were conscious of translating aspects of its form, structure, and content online. Design decisions were deliberately made to preserve the core learning outcomes of the original face-to-face setting while allowing for significant flexibility for students to experience design thinking education as immersively as possible.

The final course learning outcomes were translated as competencies, and aligned with the overarching goal of building creative confidence, as follows:

1. Substantiate and justify the importance of creativity and innovation with a solid understanding of why they are necessary to survive in today’s highly disruptive environment
2. Appropriate the use of creativity and innovation tools, frameworks, models, and processes to various contexts including barriers, opportunities, and challenges
3. Design and champion ethical solutions that address real-world needs by mastering creativity and innovation principles
4. Develop viable solutions by integrating creativity and innovation in a holistic way to achieve strategic organizational success or competitive advantage

#### 2.2.1 Kolb’s Experiential Learning Cycle

The course is typically aligned with Kolb’s experiential learning cycle as it is parallel to the principles of design thinking (Beckman & Barry, 2007), simulates real-world scenarios, and is appreciated more by the so-called generation Y (Deutschmann & Botts, 2015). Design thinking in itself is an example of experiential learning (Deutschmann & Botts, 2015). Kolb & Kolb (2005) describe the experiential learning cycle as composed of four stages:

1. Concrete experience, where learners immerse themselves in new experiences without bias
2. Reflective observation, where they reflect on their experience from different perspectives
3. Abstract conceptualization, where they analyze their experience and reflections to form logically sound theories

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4. Active experimentation, where the theories are used as a foundation for problem-solving and decision-making

Through this cycle, learners recursively grasp and transform experiences to constantly learn and relearn (Kolb & Kolb, 2005). In the traditional classroom set-up, students could go through the cycle recursively and without delay. However, the challenges brought about by the pandemic, both anticipated and unforeseen, were disruptive to the experiential learning cycle. To illustrate, here are just a few examples of how it was impacted by the transition:

- Students could no longer conduct fieldwork and observe people and events in their natural environment, which hindered them from maximizing concrete experiences.
- Typically, students rely on teachers as a sounding board for their reflections, ideas, and theories. As anticipated, there became delays in giving feedback to students.
- Students also rely on feedback from peers, which they used to easily ask and receive through everyday interactions both inside and outside of the classroom. Without these, feedback from peers was no longer as convenient or immediate.

2.2.2 Methods in Design & Execution for Online Learning

The course design can be divided into three phases that reflect metadisciplinary approach of design thinking both as the theoretical grounding of the course and the faculty’s practical application in creating, teaching, evaluating, and adjusting the course components. These phases also reflect the make-observe-reflect model of the creative process (Dubberly Design Office, 2009), but adapted as create-teach-adjust in the context of making the course, teaching the course, and adjusting the course design and requirements iteratively and recursively.

These correspond to validating the anticipated and unforeseen challenges previously indicated in Tables 1 and 2, represented by numbers within the parenthesis format (e.g. #A1), although not all stages of the course design have a direct and corresponding issue or challenge that it tries to solve.

(1) Course Development Phase

This covers course preparation from the design team and the process by which each building block of the course was created, configured, and adjusted to become ready for publishing in the LMS.

1. **Timeframe.** Plotting the new 7-week timeline for intersession as directed by the university administration was essential in imagining the course structure. Course development started one month before the first day of the semester.

2. **Learning Outcomes.** The core lessons retained were aligned with learning outcomes set together with the department. This dictated which of the foundational topics across the four modules of (1) Creativity, (2) Design Thinking, (3) Strategic Innovation, and (4) Commercialization were crucial in delivering the outcomes that were ultimately framed as competencies instead.

3. **Assessments.** Assessments were formulated before creating course content to be consistent with university guidelines on adaptive design for learning, which implemented Backward Design (Wiggins et al., 1998). This also involved rethinking how formative and summative assessments were conducted in the environment created through the LMS, i.e. objective quizzes and long tests were transformed in favor of qualitative graded discussion prompts and reflective course syntheses. The summative capstone project was retained as a major requirement that applied course lessons in conjunction with the learning outcomes and competencies. (#B2, #B3, #C1)

4. **Structure.** Similar to the findings of Rauth et al. (2010), the modules and course building blocks were presented linearly to introduce the concepts of design creativity to first-time students and factor in the limitations of the LMS. However, the capstone project and the majority of the requirements were realized and experienced in an inherently cyclical manner reflecting the iterative nature of design thinking. Students constantly sought and applied feedback from their projects’ target users, improved and adjusted solutions that were ideated, and built and refined more features in streamlining their prototypes.
5. Learning Management System. Understanding the structure and technical limitations imposed by the LMS was also a crucial factor that influenced the course design. Canvas (http://www.instructure.com) was the university-mandated LMS that offered an interface that can be populated by original content written by the team, sourced academic references for topics, as well as rich media and collaborative third-party digital tools that can be embedded for the students to access. However, the LMS was limited in terms of its inability to document the design thinking process that each student group went through for their projects, as publishing content in Canvas only captured its end and final state without a viewable history of its changes and evolution. Faculty extended the flexibility for students to choose any platform that suited their creative process best.

6. Content writing and adaptation. The design team collaboratively generated a unified outline that included required topics that must be present for all sections of the course. Populating this on the LMS with lesson content was achieved by dividing the team into three groups where teachers built on existing course material (presentations, cases, capstone project guidelines) to write the modules. Teams proofread each other’s topics and a fourth group was created to conduct quality assurance of both originally created and externally sourced curated content. The difference in writing styles and language was later adjusted by review and edit sessions with the team. (#B4)

7. Estimating learning time. Learning time of around 8 to 10 hours per student per week was advised by the university, which included reading assigned reference material, watching or listening to a live or prerecorded lecture, participating in discussions (whether synchronously or asynchronously), working on an individual task or group project, and taking assessments. Initial feedback from students indicated that total actual learning time, especially due to the group-oriented nature of the activities, was more than what was estimated. (#B4, #B5)

8. Content customization. Teachers were allowed to individualize content according to their expertise. Two lenses were applied: (1) a “corporate” model where course content revolved around companies that already have established footing in specific industries. This was developed for students who planned to join corporations after graduation and highlighted problem-solving within specified boundaries and contexts of a given organization. The second was a (2) “startup” mentality where students generated unique and novel ideas that did not have any precedents or precursors that are already commercially available. These two lenses are most evident in the execution of the capstone project, but it must be noted that both approaches are not necessarily mutually exclusive from one another in terms of foundational knowledge of the course’s core content. (#B2)

9. Digital tools. Multiple third-party tools such as Padlet, Google Suite, Jamboard, and others were integrated into the LMS to help visualize and aid students in their design thinking tasks. Video editing software, prototyping apps, and mind mapping tools were also used. (#A2, #B1, #B2, #B3)

10. Visuals. Visual branding for the LMS was created to aid students in their learning experience: (1) a visually striking frontpage was created to emulate popular contemporary interface design aesthetics to ease the students’ transition into online learning, and also brand the school of management’s courses with a consistent style. (2) Module headers were used as visual signals to indicate if a particular section within a page was an assignment, graded discussion, required reading, or video, etc. We wanted to clearly signal to the student if there was a deliverable, or information that needed to be highlighted. (3) A unified visual information hierarchy created consistent fonts and text stylization across the modules authored by different teachers.

11. Rebranding and hype-building. Cognizant of the course’s rather fast timeline and pacing, and an inevitable learning curve presented by a new LMS online, the course was framed as a specially designed “Innovation Bootcamp” version for the intersession. This rebranding aimed to manage the expectations of the students in the course design given the challenges imposed by the pandemic. “Marketing” materials were developed to influence student engagement by creating weekly newsletters that included the scope of topics in the upcoming week, reminders for deadlines, and course events. This is a commonly used technique in MOOCs that was adapted by and sent through the Announcement section of the LMS, and the students’ university email addresses to urge course completion and timely submission of assessments by the students. (#E1)
(2) Teaching Phase
This phase refers to the teachers’ actual teaching period with the students during intersession. Course preparation was also conducted concurrently due to the iterative nature of designing and adjusting course components. Observations by the teaching faculty were carried out in this phase as well that factored into the third phase of the course.

12. Teaching timelines. Half of the total course content was initially published at the beginning of the semester with assessments and corresponding deadlines. This created a flexible and asynchronous self-study pace for the students while maintaining a common structured timeline that preempted the possibility of cramming the course. Students indicated that a long-term view of deliverables helped manage their schedules effectively, with the visibility of course content as a function of how they can independently manage their time given the workload. (#A3, #B4, #E1)

13. Synchronous sessions. A prescribed once-a-week schedule for synchronous sessions via video calls were conducted following the course timeline. These were announced with considerable lead time, did not require student attendance, and were recorded and released for students’ reference. Content varied for each teacher, which may be a synthesis of each module or an overview of certain topics. These synchronous sessions also became an opportunity to supplement learning by allowing students to raise clarifications about lessons or requirements. (#A1, #B4, #E2)

14. Departmental webinar. Previously, supplemental topics were discussed by inviting guest lecturers to the campus or arranging a field trip to a company. This was adapted into an online departmental webinar, where given scheduling conflicts, teaching faculty agreed to independently schedule guest speakers to suit their respective sections’ availability and progress in the course. Invitations to the speaking events were extended to all DECSC25 sections for students to freely select topics and speakers they found interesting and relevant. (#B1, #B2, #B3)

15. Communication channels. Teachers’ availability for consultation and coaching was a priority given the assumption that online learning will pose challenges to communicating concerns about course activities. Group chats with students were created using social media platforms like Facebook Messenger and Viber. Although consultation schedules were formally announced on the course syllabus, these chat groups allowed students to reach out in real-time and created an impetus for teachers to respond within reasonable hours. (#A4, #A5, #F1, #F2, #F3)

16. Student touchpoints. Surveys and polls that served as temperature checks for the students were also conducted through the chat groups. This involved qualifying their emotional state into emojis or using a scale to rate the quality of their overall experiences regarding the course or intersession as a whole. Student groups also had weekly calls with teachers for progress updates and feedback for their capstone project. (#A2, #A4, #A5, #B6, #F1, #F2, #G1, #G2, #G3)

17. Faculty touchpoints. Weekly touchpoints among faculty members via chat or video meetings were created for knowledge sharing and overseeing the degree of consistency that was applied when proposed changes or adjustments were implemented in their respective sections. (#A4)

(3) Adjustment Phase
Due to the feedback and observations from student touchpoints and the university’s findings during the teaching phase, both major and minor modifications were applied to the course in order to respond to unanticipated challenges posed by online learning during the pandemic.

18. Readjustments on assessments. Course requirements were streamlined to help students balance workload together with other courses taken concurrently for the semester. The faculty had the discretion to adjust the quantity and structure in concurrence with the department and students. This resulted in a prioritization exercise to determine which assessments were crucial to building the competency-based learning outcomes, and a collaborative effort within the department to restructure the course from a content perspective. Implications on grading components for any changes were also aligned departmentally to maintain consistency across all sections. Among those changes included tagging certain topics as additional source material that students can have the option to study, eliminating one of two case studies, and reducing the number of graded discussions in favor of free-form “think and
share” prompts that allowed students to submit interpretations of formative questions in a non-restrictive format and structure. (#A5, #B6, #B7, #C2, #D1, #D2, #D3, #G1, #G2, #G3)

19. Readjustments to the capstone project. The usual format for grading the project involved assembling a panel of judges for a live presentation and Q&A session immediately afterward. Scheduling conflicts resulted in having the panel judge and grade projects asynchronously through tools like Google Sheets. A degree of variance was allowed for the format of the final project deliverable with respect to the individualization applied. For example, teachers who chose to have a “corporate” lens structured projects to resemble proposals to implement creative solutions for an existing company, represented by a judge in the panel. Students who chose a “startup” setting had the opportunity to create public announcements of their projects, which were innovative solutions applied as startup business ideas and delivered through website mockups, social media campaigns, petitions, and working prototypes. Judges were invited to “invest” seed money (that were simulated amounts rather than actual funds) to projects given a set of evaluation criteria that was similar to the corporate rubric as well. A virtual gallery of the final projects was published by the department. (#A5, #B6, #C2, #D3)

20. Course synthesis. In place of a final exam, the students were asked to synthesize their individual takeaways from the course and conduct an analysis of the knowledge they acquired, as well as skills and competencies they developed. They contextualized their learnings with a comparison of their understanding of creativity and innovation prior to taking the course, their experience taking it, the mindsets, methods, and behaviors they acquired, and their outlook on creative thinking moving forward. (#B4, #G1, #G2, #G3)

21. End of course survey. Students were also asked to provide feedback regarding the course in terms of how they perceived the content, assessments, and their experience with the teacher.

2.2.3 Redesigning the Course for Online Learning using SAMR

Following the Substitution Augmentation Modification Redefinition (SAMR) Model discussed by Puentedura (2014), activities and requirements were translated from the traditional classroom set-up to online learning. To address some of the experiential learning cycle delays caused by the transition to online learning, tasks were transformed and enhanced. Table 3 shows concrete examples of this.

Table 3. Enhancement and transformation of traditional classroom activities for online learning using Puentedura’s SAMR model

<table>
<thead>
<tr>
<th>Traditional Classroom Set-Up</th>
<th>Online Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Redefinition:</strong> Tech allows for the recreation of new tasks, previously inconceivable</td>
<td>The online course simulated a more realistic experience of starting a new business or implementing a solution for an existing corporation. Students were required to create a prototype of their conceived product or service, gain feedback from target users, and publicly launch their business to gauge market interest.</td>
</tr>
<tr>
<td>For their capstone project, students submit a paper and present it to a panel of experienced professionals.</td>
<td>Teachers conduct weekly cadences to check-in with the groups via video call, discussing updates on their progress and immediate feedback on the building blocks of their projects.</td>
</tr>
<tr>
<td>Students have the option to pass drafts of the paper required for their capstone project.</td>
<td>Students have creative freedom over submissions, i.e., they may submit podcasts, drawings, infographics, etc. to articulate their learnings and accommodate multi-modal answers.</td>
</tr>
<tr>
<td>Students are required to submit papers as their requirements.</td>
<td>Students watch and reflect on a discussion prompt or question, then answer via discussion boards. They can comment and discuss their classmates’ input without a time...</td>
</tr>
</tbody>
</table>
In class, students discuss one wicked problem and trace it to different causes.

Each student identifies a wicked problem they’re interested in, traces it to different causes, and maps it to the rest of the class’s wicked problems and causes via a visualization tool like Padlet.

**Modification:** Tech allows for significant task redesign

In class, students bring foods with contrasting flavors and try them together to practice the da Vinci principles of *sfumato* and *sensazione* (Gelb, 2009).

Students reflect on which da Vinci principle they have developed the least and perform activities relating to the principle. Assessment for this topic required students to document findings over three weeks, which enabled them to build habituation for their selected da Vinci principle.

**Augmentation:** Tech acts as a direct tool substitute, with functional improvement

Students conduct fieldwork to empathize with their target community.

Students leverage on social media to identify the target community’s sentiments in addition to reaching out via phone and/or internet.

Students keep up with the pace of the class, consulting with peers and/or teachers if they have clarifications.

Students may reread or rewatch resources at their own pace until they sufficiently grasp the concept, with the option to consult their peers or teacher, as well as share new insight and ideas they discover to enrich the class’ discussions.

In class, students discuss a concept while the teacher mind maps their points on a whiteboard.

In a video call, students discuss a concept while the teacher mind maps their points using an online tool (e.g. MindMeister). Students are free to use the online tool directly too or choose other tools that they find appropriate for the exercise.

Students were either invited to a talk by a professional or a field trip to a business’s office.

Webinars on different topics were done by professionals. The new set-up allowed bigger audiences and better access to the speakers since travel time and room capacities were eliminated.

Practical application of creative thinking tools involved creating physical materials like post-its, paper, cards, etc.

Creative challenges in the course allowed students to survey digital tools that could mediate their collaborations online. These tools are more robust in terms of being able to document the changes and evolution of students’ output and be adaptable in generating multiple formats.

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**3. Results**

The metadisciplinary approach taken in designing the course delivered results better than expected. In terms of content, the online course was able to aggregate a rich set of creativity and design thinking resources stemming from the joint effort in course development by the design team and teaching faculty, and the ability of the learning management system’s interface to integrate related tools and host course materials. Multi-modal discussion boards afforded all students the opportunity and time to voice out opinions and insights in formats that may not have been possible in a classroom setting. The collaborative nature of the coursework reinforced habituation in the application of creative methods, where students iteratively exercised key concepts in the design thinking process to deliver requirements, and autonomously seek design-oriented approaches to problem-solving.

Ultimately, even though this was a pilot with fair opportunities for further refinement in succeeding semesters, it can be argued that the very circumstances that created an impetus for developing the course online subjected both students and teachers to a much deeper and profoundly intense immersion in a design thinking mindset amidst a pandemic. This is concretely manifested in the capstone projects submitted, where the majority of the assumptions and contexts factor in the complexities surrounding the biggest
simultaneously global and local issue of our time. Teachers applied design thinking itself into an extensive understanding of the pandemic’s issues in how guidance and academic advice was provided to enrich the students’ outputs. Notable capstone projects include:

- A mobile application to make travels safer and more personalized by connecting travelers to locals, visualizing itineraries, and making all relevant travel information accessible
- A do-it-yourself soap kit with customizable scents and fun designs to combat negative perceptions of handwashing among children
- An affordable radio-powered tablet designed specifically for high school students foraying into online learning in remote rural areas in the Philippines
- An application that recommended computer models and shops best suited for online learning given a particular budget

It is also important to note that while the experience itself presented many challenges for the students, the quality of output and academic performance demonstrated in the online course did not indicate a difference in quality versus the output in previous semesters. Teaching faculty were able to successfully facilitate the pilot without compromising the quality of assessment submissions, as evidenced by the meticulousness and level of analysis performed by the students. We can definitely say that cognitive knowledge transfer was achieved through the design decisions made for the online course, in addition to accounting for the students’ emotional and motivational abilities in its delivery.

Firsthand accounts from students through their summative course syntheses also strengthen and affirm the fulfillment of the desired competencies. Students were able to concretely identify changes in their behavior with respect to their self-perception of creativity, noting that the skills they developed and mindsets they cultivated during the semester contributed to a greater trust in their own creative skills that they did not acknowledge prior to taking the course.

4. Discussion

The challenges posed to delivering the course online during the pandemic were overcome by taking a metadisciplinary approach to (1) identify blockers to the experiential learning cycle; (2) redesign activities and requirements following the SAMR model and learner-centric principles, and (3) simultaneously teach and redesign the course depending on the students’ needs and overall context of the semester. Through these measures, the team was able to effectively deliver the course lessons online, and by extension, successfully build creative confidence as a core competence for the students.

The success in delivering the course online is validated by the three important factors Lloyd has identified as contributors to successful online learning for design (as cited in Taheri & Meinel, 2015, pp. 471-472). In Table 4, the factors are shown alongside the measures taken to adapt to the online environment. Although other efforts to deliver the course effectively are not specifically aligned with these factors, they were still relevant as they helped overcome the challenges presented.

Table 4. **Lloyd’s factors for successful online learning for design**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Efforts taken for DECSC25</th>
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<tbody>
<tr>
<td>Introducing creative social networks that serve as a broader audience and provide feedback</td>
<td>- Requiring feedback from users at different stages of the process</td>
</tr>
<tr>
<td></td>
<td>- Hosting webinars with professionals in the field</td>
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<tr>
<td></td>
<td>- Inviting professionals as panelists for the capstone project</td>
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<tr>
<td></td>
<td>- Requiring feedback from their peers</td>
</tr>
<tr>
<td>Defining design not just as creating aesthetics artifacts, but also encompassing different areas like communication</td>
<td>- Allowing students to submit requirements in any format</td>
</tr>
<tr>
<td></td>
<td>- Introducing design as the intentional facilitation of group sessions</td>
</tr>
<tr>
<td></td>
<td>- Introducing user experience to emphasize function as design</td>
</tr>
<tr>
<td>Communicating feedback effectively online</td>
<td>- Conducting informal check-ins with students via social media</td>
</tr>
<tr>
<td></td>
<td>- Conducting weekly check-ins for their capstone projects</td>
</tr>
</tbody>
</table>

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● Holding frequent consultation hours (i.e. 2-3 times a week)
● Providing detailed and actionable feedback on submissions

These are the key insights that led to students becoming more confident in their understanding of the course and consequently, their creativity:

- Students could go through the experiential learning cycle at their own pace because of the asynchronous set-up combined with synchronous sessions, weekly check-ins, official consultation periods, and informal consultations over chat.
- Strong and persistent efforts to communicate topics and deadlines periodically with stimulating visuals helped students develop an inclination to go through the LMS, set their own pace, and manage their time and workload despite the challenges external to the course.
- Weekly check-ins allowed for feedback to be given more immediately as the students progressed through their capstone project. Teaching faculty had the opportunity to ground the foundations of the project in the context of the pandemic and reinforce problem-solving mindsets.
- Simulating real-world market acceptance of products and services established creative design thinking into creative design doing.
- Formative assessments, such as reflection papers, cases, and discussions prompted by open-ended questions emphasize the creation, framing, and validation of students’ unique insights rather than a prescribed analysis or synthesis of ideas. This is consistent with viewing the application of design thinking as a learning model that supports creativity (Rauth et al., 2010).
- Giving students the freedom to decide the format of their submission (e.g. text, drawings, presentations, collages, music playlists) helped unleash their creativity. It was also considered stress-relieving for some who chose to align their format with their hobbies and interests.
- Consistently gauging the feelings of the students throughout the semester via surveys, polls, or informal conversations enabled the teachers to adjust and redesign the course as necessary.

Overall, we strongly affirm the hypothesis that the deliberate design choices made throughout the development of the course were able to successfully deliver the learning outcomes not only consistent with previous semesters, but also with a greater opportunity to immersively experience design thinking education. We can also assert that the adaptation of design thinking principles in an online learning environment was successful in its purpose of cultivating creative confidence among students. We recommend for succeeding semesters to further streamline the process of restructuring assessments to have a tighter holistic approach in conjunction with the capstone project, but still value the diversity of possible output from students. Future research can focus on the impact of applying specific course design methodologies to other subjects being adapted online.

Acknowledgements

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Empowering Learning Designers through Design Thinking

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Abstract: The COVID-19 crisis has compelled universities world-wide to make urgent and unexpected changes in the delivery of education. Transitioning from face-to-face to online teaching has presented a major challenge for some. Given the content is provided by the content experts (university teachers), a question arises whether the learning designers are ready for this challenge and can align their expertise to the requirements triggered by the pandemic. Learning designers need to have skills that can connect learning objectives and activities to changing contexts and changing stakeholder needs. Design thinking is proposed as a useful strategy which learning designers can use to address these challenges. This session will use action research and involve attendees in questioning how design thinking may support academics and learning designers in providing better experiences for learners.

Keywords: Learning design, Learning designers, Instructional design, Design thinking, support and strategies

1. Introduction

During 2020, COVID-19 emerged as a major social and economic challenge. In the education sector, it caused universities to face the challenge of swiftly moving from face-to-face teaching to online – and for many institutions this has been a new experience. Transitioning from face-to-face to online teaching presents a major challenge for Learning Designers (LDs) perhaps because they are “the sherpas of online learning teams” doing the “heavy lifting” for university teachers preparing to teach in unfamiliar remote and online contexts: “the successful transfer of knowledge, the stimulation of creative thinking and the development of critical insights all rest on the preparation, organization and stability that this small army of specialists (LDs in our context) provide” (Levander & Decherney, 2020). Apart from this unprecedented situation, historically LDs have also had to keep up with relentless and sometimes disruptive technological change and teaching models. This paper argues, however, that LDs may not have relevant qualifications or experience to support this wide range of tasks that they are expected to carry out. While they provide support to content experts, they also need support.

The first author of this paper is a learning designer and has faced the uncertainty in expectations. She has struggled to keep up with demands and tried to learn new skills that could assist in gaining clarity and expertise in learning design. Design thinking, as a broader field, has proved to be a useful strategy facilitating stakeholder engagement with the creative process. It is proposed here as a useful strategy in designing for learning. Hence, design thinking is presented as one of the strategies that LDs could use to enhance their understanding of the process of learning design.

2. Learning Design (LD) – Historical perspective

The historical origins of the field of Instructional Design (ID) lie in World War II wherein American Army Air Corps was deemed to be very high, experts in education and psychology were engaged to develop training materials based on instructional principles. The instructions can influence the environment (Clark,
Skinner (1963) proposed that the learning environment could be manipulated by putting the right learning process in place, a process he named programmed instruction. Skinner’s “teaching machine” was one noteworthy technological embodiment of his ideas and research, a machine that arguably is now reappearing in classrooms in the form of tablets and devices that lead students through adaptive learning exercises (Skinner, 1958). In the decades since WWII, the field of ID has been thoroughly researched and has opened new frontiers. The generic term ID was used for all attempts to design a task that has gone through various changes and challenges. After this profound foundation, ID developed in a more structured manner, and many research-based models have flourished to support the field, including: ADDIE (Clark, 2004), backward design (Wiggins & McTighe, 2005), the Four Component ID Model (4C/ID) (Merriënboer et al., 2002), Dick and Carey Model (Dick, 1996; Dick & Carey, 1978) and so on. With development in Information and Communication Technologies (ICT), ID has shifted from a focus on the organisation and sequencing of learning resources and material to a more holistic approach and acknowledgement of the learning environment and shifting emphasis to the learner. In other words, the scope of learning design has widened from a focus on the learning artifacts to the influence and potential of the learning context.

Learning design is a much newer field of design and practice emerging early in the twenty first century (Dalziel, 2016) and promoted by the IMS Global Learning Consortium around 2002. The main difference between learning design and ID is that learning design incorporates affective engagement of learner and developed at a time in Web development where the ‘end user’ increasingly became recognised as the most important stakeholder. This allows subjective perception along with understanding of collective co-creation of meaning (Parchoma et al., 2019). The shift in terminology was also in sync with the trend toward the learner or the “user” becoming the most important stakeholder in the web. The web itself has been a great catalyst for self-directed learning.

3. Background and challenges

With the change in focus for learning design work, there have emerged many challenges. The first and foremost challenge is that university teachers are not typically trained as learning designers and people who are learning designers do not necessarily have the range of skills required for the the changing digital environment. Wasson and Kirschner (2020) explained this with a metaphor of a chef. As the chef would have the ability to make use of tools and techniques of cooking along with knowledge of ingredients. Most importantly the chef would have “the requisite deep knowledge, skills, attitude, and experience to know what to use with what as well as how and when to use them to create delicious, nutritious, and beautiful meals”. Similarly, in a study situation/learning environment, learning design involves use of tools (technology), techniques (pedagogy) and ingredients (content knowledge) to create a meaningful learning experience for the students. These challenges lead to many questions that may be out of scope of this paper. However, one of the things worth investigating is what the learning designers do. If we review the job market in the last decade or so, there are positions for learning designers created across almost all industry sectors. In personal conversations with many employers about the role of the position has indicated there is no coherent or shared understanding of what a learning designer is and what the knowledge base is required to become a successful learning designer.

Another challenge comes from the background of the people involved in learning design. Because most of the tasks are designed by academics in higher education and they are not trained designers, empowering them to design better tasks is a challenge. Wasson and Kirschner (2020) say “he [learning designer] also has the requisite deep content, pedagogical content, technological pedagogical content knowledge and skills, attitude, and experience to know what to use with what, as well as how and when to use them to create effective, efficient, and enjoyable learning experiences”. This would mean being a learning designer is a challenge because it requires them to possess a wide variety of skills. Hence supporting them is a challenge for the institution. Wasson et al further analyse this challenge and note that there is a growing body of what works and why (evidence base) in the learning situation but at the same time there is a huge amount of misinformation which they call pollution in the learning design ecosystem.
For learning designers to use the research evidence and base their practice on best practice, they need to have access to authentic scientific literature which is often behind the paywall. There are other peripheral issues around correct use of data available and learning designers’ ability to understand statistical and methodological knowledge.

The above challenges indicate why learning design is a field that requires attention. Kickbusch et al, (2020) after a comprehensive literature review, suggest that “learning design remains misunderstood, misaligned with the practices of instructional design, and confused by the exponential growth of educational technologies”. Most higher education institutions have created position of learning designers indicates that there is a substantial unmet demand of usable form of guidance. The demand from academic staff, being time-poor, to help with “for customisable, re-usable ideas, not fixed, pre-packaged solutions” (Goodyear, 2005). Universities and institutions have employed large number of professionals with varying job titles basically trying to meet this demand. The following sections presents some empirical evidence demography of learning designers and their roles.

4. Who are learning designers?

A study conducted in 2016-2018 by Slade et al. (2019) was focused on Learning designers’ roles in Australian universities. It reveals a lot about the field. The study collected responses from 103 learning designers and 16 learning and teaching leaders about their roles. The study revealed that the learning designers conduct various tasks as a part of their work as indicated in Figure 1. LDs are involved in various tasks under the broader umbrella of learning, creativity, technology and business. The survey also revealed that 98% of designers manage Learning Management Systems (LMS) and only 13% are involved in research and have publications.

What do Learning Designers do?

![Figure 1. Roles and frequencies of activities of learning designers](image)

This the study also revealed that about 71% of the LDs have postgraduate qualifications. Because the LDs are a core part of creating technical and pedagogical priorities for the learning environment and the variety of tasks that they do, they overlap the boundary between academic and professional roles. This blurring of
roles creates ‘third space professionals’ wherein the LDs create a highly collaborative environment for themselves and others in the team. The concept of the ‘third space professionals’ articulates the opportunity to consider new identities as staff, such as learning designers, step into the professional space of other staff, such as academics or other professional staff who support teaching (Slade et al., 2019; Whitchurch & Gordon, 2010).

This research further investigated the reasons for LDs to work in this area. They all ended up in this field because of their interest in education and writing, a curiosity to understand things more deeply, and a desire to help people. Because that the learning design professionals may have different qualifications, interests and have wide variety of skills, and that they do not necessarily have the background that they need, creating a supportive environment could be challenging.

5. Supporting learning designers

As mentioned above, to be a good learning designer, one needs to have wide variety of skills and knowledge in various areas such as teaching and learning, technology, teaching philosophies and deep understanding of how people learn. Besides, the learning designers also need soft skills such as collaboration, teamwork, some research skills and intuitive judgement (Jen, 2018). Given the challenges mentioned in above section, the learning designers seem to have a critical role to play in laying out the engaging teaching and learning plan.

The question now arise is how best learning designers could be supported to carry out these tasks. The definition indicating the characteristics of learning designers (she called it eLearning Champions then) by Beath (1991) is useful here. “Individuals who emerge to take creative ideas (which they may or may not have generated) and bring them to life. They make decisive contributions to the innovation process by actively and enthusiastically promoting the innovation, building support, overcoming resistance, and ensuring that the innovation is implemented”

The characteristics of learning designers mentioned above resonates with design thinkers’ mindset which is being comfortable with open-ended situations without predetermined outcomes; being empathetic to the needs of the user and engaging in exploration and managing uncertainty, taking calculated risks, learning from failures and relying on personal judgment rather than accepting existing solutions (Gachago et al., 2017).

6. Design thinking as strategy to support learning designers

It is proposed that design thinking methodology (Norman, 1998) could be one of the strategies to equip learning to face the challenges described earlier. The rationale for using design thinking as a support mechanism include:

- Design thinking can lead to solutions that are not apparent with our initial level of understanding
- Design thinking does not assume the person using design thinking to be master designer.
- Design thinking is creative process and better solutions can be reached by the iterative process.
- Design thinking is user centric and hence can be useful in creating engaging student-centred educational setting.
- Different variations in design thinking process can be used for different learner needs.
- It is agile and can absorb any changes
The various stages depicted in Figure 2 will be elaborated on to attendees of the workshop with a view to stimulate discussion around if and why design thinking can be used by learning designers so they can be better supported and trained to face the challenges of this field.

7. Proposed activity

Depending on time available at the workshop a short action research survey will be introduced to solicit views of the participants on using design thinking in learning design. The responses then will be used for the further research in the area.

References


Keep Online Design Thinking Alive: a Case Study in Indonesia

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bUX Indonesia and Charles Darwin University, Indonesia and Australia
*el_yulaikha@prodes.its.ac.id

Abstract: COVID-19 pandemic has disrupted the way teaching and learning have been conducted at the university in Indonesia. None of us have experienced tackling this extraordinary situation. Prior to the pandemic, face-to-face learning mode has been the primary preference in university education. Some universities in Indonesia have used online mode as a support for the main offline teaching and learning, but the focus was more on administrative activities, such as: submitting assignments, sharing resources, and sending announcements. However, the COVID-19 pandemic has left the universities with no choice, but to switch their education from offline to fully online. However, in the case of Design Thinking courses, offline interaction might not be the best as intense interaction is required to achieve the goals. This study investigates the challenges and potentials of conducting online Design Thinking courses, which is in this case, the Design Research course. Using the Design Thinking 2.0 framework, we have analyzed and identified several interventions that we propose in this paper to leverage and transform the current course.

Keywords: COVID-19, Design Thinking, Design Research, Creativity, Indonesia, online learning, face-to-face learning

1. Introduction

COVID-19 pandemic has changed the way teaching and learning are conducted at most universities in the world, from offline to fully online mode. However, online learning is not always easy to implement and brings satisfaction for educators and learners, especially when the subject requires intense physical presence and face-to-face interaction, like the Design Thinking course.

Design Thinking is an iterative design process that belongs to every level in the organizations (Brown) to solve a wicked problem (Rittel, H. W., & Webber, M. M., 1973). The results of the final stage of the initial work help to inform the next design process until new alternative solutions are developed. Design Thinking is a non-linear iterative human-centred design process to solve wicked problems.

Design Thinking 2.0 (see Figure 1) introduced by the second author, is an advanced version of the Design Thinking framework (Sari, 2020; Tedjasaputra and Sari 2020). In this framework, the design and development process is entwined with each other. The flexibility of iteration in each stage is an additional advantage in Design Thinking 2.0. Furthermore, time-boxing is another built-in property of Design Thinking 2.0 that supports creativity and people's time to be involved in the process. The time-boxing is also the disadvantage of Design Thinking 2.0, in which a complex product that requires longer time to develop will not fit into this framework. In this paper, we will use Design Thinking 2.0 as a framework to analyse the online Design Thinking course.

Learning about Design Thinking at the university needs to provide an authentic experience and ensure students master the key skills that they can apply when they are at the workplace one day.

This study describes an education project done by the first author, who is the lecturer of the Industrial Design Department in a public university in Indonesia. She and her team teach two Design Thinking courses under the names of Design Research and Creativity for the 6th and 7th-semester bachelor students. The Design Research course is a prerequisite introductory course that final design students must take before they do a final project, whereas the Creativity course was an enrichment course intended for non-design students who are interested to learn about Design Thinking and Creativity. In this paper, we will discuss one of the courses, which is Design Research.
The Design Research course is an introductory course to prepare students for their final project. The topics discussed in this course include Design Thinking, Design Methodology, Design Ethnography, Creativity, Primary and Secondary Data Collection Techniques, Business Analysis, User or Customer Analysis, and many more. By doing this course, some of the key skills expected to master include implementation design concepts into design alternatives, visualization of design alternatives using manual and digital media, application of design thinking principles in data collection, determining design methods, and applying UX research theories to understand target markets and inspire design (UX Design, Ethnography, Persona, Customer Journey Mapping), prototyping and development. Before the pandemic, it was run in classrooms, studios, and labs with industry stakeholders.

Table 1 and 2 show learning outcomes, contents, and classwork from the Design Research course.

![Design Thinking Process](image)

**Figure 1. Design Thinking Process**

**Table 1. Learning Outcomes of Design Research Course**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Able to implement design concepts into design alternatives.</td>
</tr>
<tr>
<td>2.</td>
<td>Able to visualise design alternatives using manual and digital media.</td>
</tr>
<tr>
<td>3.</td>
<td>Able to apply design thinking principles in data collection, determination of design methods, and analyses required in formulating design concepts.</td>
</tr>
<tr>
<td>4.</td>
<td>Able to present design projects through academic writing, posters, and verbal presentations.</td>
</tr>
<tr>
<td>5.</td>
<td>Able to apply user-related theories to design projects, such as user experience design, personas, consumer journey mapping.</td>
</tr>
<tr>
<td>6.</td>
<td>Able to construct design concepts based on considerations of needs, technological feasibility, and environmental and responsible business considerations.</td>
</tr>
<tr>
<td>7.</td>
<td>Able to collaborate with various parties in managing design research.</td>
</tr>
</tbody>
</table>

**Table 2. Weekly Learning Content and Class works**

<table>
<thead>
<tr>
<th>Weeks</th>
<th>Titles</th>
<th>Contents</th>
<th>Class works</th>
</tr>
</thead>
</table>

504
<table>
<thead>
<tr>
<th></th>
<th>Exploring Research Topics</th>
<th>Design Research Secondary Data Research Skills Scope of Work and Possibilities</th>
<th>Mind Mapping</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Understanding Context</td>
<td>Identify stakeholders - socio-economic issues - who are the users and their needs - product design opportunities</td>
<td>Visualization of Context: Product Transformation and Stakeholder Relationship</td>
</tr>
<tr>
<td>4</td>
<td>Design Methodology</td>
<td>Designing flow of research Steps and Sources of Information Data Collection Plan &amp; Detail Validity and Reliability of Data Research Ethics of Primary Data Data Collection Procedures</td>
<td>Scheme of Design Method and Data Collection Plan</td>
</tr>
<tr>
<td>5</td>
<td>Primary Data Collection</td>
<td>Design Experience: Visceral, Behavioural, Reflective Data Collection Plan and Challenges</td>
<td>Collecting Primary Data</td>
</tr>
<tr>
<td>6</td>
<td>Market Analysis</td>
<td>Market Segmentation, Targeting and Positioning</td>
<td>Conducting Market Analysis</td>
</tr>
<tr>
<td>7</td>
<td>User Analysis</td>
<td>Methods to build user empathy Introduction to Persona Introduction Scenario, Storyboard and Customer Journey Mapping Predicting User Experience</td>
<td>Develop Persona</td>
</tr>
<tr>
<td>8</td>
<td>Design Requirement and Objectives</td>
<td>Affinity Diagramming or Objective Tree</td>
<td>Making Affinity Diagramming</td>
</tr>
<tr>
<td>10</td>
<td>Preliminary Design</td>
<td>Selecting Prospective Design Turn Prospective Design to Design Alternatives</td>
<td>Proposing Three Design Alternatives</td>
</tr>
<tr>
<td>11</td>
<td>Design Selection</td>
<td>Preliminary Design Comparison</td>
<td>Design Presentation</td>
</tr>
<tr>
<td>12</td>
<td>Design Resume</td>
<td>Abstract, introduction, design problems, design goals, methods and solutions</td>
<td>Write one page abstract (200 – 400 words)</td>
</tr>
</tbody>
</table>
The Design Research course requires intensive interaction amongst students, lecturers, external stakeholders, and target users. All the activities are designed using problem and project-based learning, and design thinking as a framework of thinking to solve the problems. When the COVID-19 pandemic happens, face-to-face classrooms could not happen anymore. These hands-on Design Thinking courses must be done online. This paper will discuss a case study on how the first author and her team experienced the challenging transition process, tackled and navigated during the transition from offline to online.

2. Case Study

This section discusses an example of how a design student at the Design Research course experienced offline to online transition during the Design Thinking process.

This student has a project to design an interactive planting media to educate primary to university students about Urban Farming. As the class started just before the lockdown, the student still had a chance to experience a few offline classes. The student could have a face-to-face interaction with the target users to build empathy. The project ideally requires him/her to work closely with students, parents, and teachers through shadowing, observation, contextual inquiry, and other ethnographic activities to understand their perspective, habits, and experience in planting at school, home, and other places. Amongst many of the activities planned were to conduct an observation when students watched a video about planting and started to create their own garden at school.

Below are the activities that are done online after the pandemic lockdown (see Table 3).

| Table 3. A Case Study of Design Thinking Online Experience |
|---------------------------------------------|------------------------------------------------|
| DT Stages       | Online Experience      |
| Empathize       | Empathy building activities cannot be done in person. Students and teachers have no access to the school garden during the lockdown, except the gardeners. This situation has disadvantaged the design student to be able to observe authentic situations and build empathy for the users and stakeholders as he/she planned before. Working with children (students) with no/a lack of prior experience in planting or farming can be challenging. |
To build empathy, the design students ended up with a literature study about children psychology, interviewed parents, and observed their own nieces/nephews who study at primary schools.

<table>
<thead>
<tr>
<th>Map and Define</th>
<th>The students map the data from secondary research and limited primary research with somehow similar target users and stakeholders to define the problems during the course.</th>
</tr>
</thead>
</table>

| Ideate and Decide | With the online guidance from the lecturers, the design student could come up with several design concepts using various idea generation techniques like mind mapping and 100 thumbnail sketches and decide to build interactive and realistic learning props, where:  
- Students can observe the growth of the roots of the plants through a glass container.  
- Students can receive responses when they touch the plants, so they can be motivated to check the plants more frequently. |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

<table>
<thead>
<tr>
<th>Prototype</th>
<th>The design student was unable to develop a prototype. They were only in the phase of reverse engineering on how the existing props work.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Test</th>
<th>The design student has not been able to test the prototypes because the prototypes require tangible interaction.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Release</th>
<th>These processes are not relevant because of the scope of the course, but the school requires students to construct design concepts based on considerations of needs, technological feasibility, and environmental and responsible business considerations.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Post-Release</th>
<th></th>
</tr>
</thead>
</table>

3. Discussion and Reflection

3.1 Empathize

The case study shows only one example of the challenges faced by students in building empathy. Their design projects aim to develop tangible products. Thus, it requires the design of students to conduct a series of ethnographic studies before the process of Ideate and Decide to build empathy for their target users and stakeholders. Some of their users are not accessible with the online medium, for example, workers in remote areas or little children who have no access to personal digital devices.
The current experience shows that the design students chose to change the building empathy plan with alternative activities, such as learning from the relevant literature, interviewing parents and children they know in their environment. The results of these activities may or may not be relevant and sufficient to get insights for the study. If this pandemic situation continues, the students will lose the learning opportunity to conduct proper empathy-building activities.

To improve this process, we suggest that a curriculum design intervention be made to ensure students have the most authentic learning experience. Some of the proposed ideas include: the department provides several dedicated projects that students can choose from.

With the dedicated projects, the schools already decide with the relevant people in the community to become the interviewees for the projects. Instead of working independently, students can work in a group of 2-4 people so they can support each other.

The assessment model needs to be improved so each student can be accessed fairly, for example, various types of assessment for each stage can be introduced, personal reflection, peer assessment, group assessment, differentiated teaching, and assessment (Lockhart, n.d.).

If the school has sufficient resources, the school may build a proper collaboration agreement with the relevant communities or organizations, where they can support with proper resources so communication and collaboration can be nurtured between them, the schools, and the design students.

The proposed activities above are in line with the following learning outcomes (refer to the Table 1 above):

**Learning Outcome 5:** Able to apply user-related theories to design projects, such as user experience design, personas, consumer journey mapping.

**Learning Outcome 7:** Able to collaborate with various parties in managing design research.

### 3.2 Map and Define

The current situation relies heavily on limited and irrelevant data collected by the students due to many restrictions to meet people face-to-face. Reflecting on this situation, if the design students can gather enough data from their stakeholders and target users, they will be empowered to map the users’ pains and gains, and define their projects better. The key thing here is the data and the ability of the lecturers to teach the students the concept of mapping and defining problems (see Table 2, Week 7).

The students and lecturers reflected that earlier this year they faced communication problems in the teaching and learning themselves. They still struggle to find the balance between the right tune and rhythm for learning online apart from the core learning itself. However, as time goes by and online learning becomes a norm, access and literacy to the technology should not be a hindrance anymore.

The challenge is how the lecturers can scaffold complex information to the students, such as: building a persona, customer journey mapping, contextual scenario, and storyboard in one 4-hour meeting and 8-hour of independent learning. There are a lot of available templates, however, templates themselves are not enough to ensure the students are able to master these key skills because each case needs personalization and contextualization.

However, having less and dedicated projects as proposed in the Empathy stage would give a better scope for the study. Other proposed solutions to ensure authentic learning is to invite guest mentors or speakers, or previous students who have taken the courses to help in mentoring the students in their independent learning.

During pandemic situations, collaboration is key to strengthening the learning community. The academics need fresh insights to check with the reality from the industry practitioners, while the industry practitioners need to go back to the foundation to ensure they are on the right track, provide a channel to contribute back to the community, and build their professional mentoring portfolio (Sari and Wadhwa, 2015).
The proposed activities above are in line with the following learning outcomes (refer to the Table 1 above):

<table>
<thead>
<tr>
<th>Learning Outcome 4:</th>
<th>Able to present design projects through academic writing, posters, and verbal presentations.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Outcome 6:</td>
<td>Able to construct design concepts based on considerations of needs, technological feasibility, and environmental and responsible business considerations.</td>
</tr>
</tbody>
</table>

3.3 Ideate and Decide

For a design student, being able to generate ideas for the design solutions is an important goal. The lecturers could provide sufficient guidance for the students to generate ideas (Ideate) and select alternative design (Decide) on weeks 3, 8, 9, 10, 11.

The experience of running offline studio-based experience has equipped the lecturers with professional tacit knowledge, skills and experience to identify problems when students expressed enthusiasm, confusion or boredom. Being able to engage students in spontaneous conversation helps students to keep on the track, challenge themselves to be accountable with any design decisions they make, and can communicate their problems.

When doing this similar process online, the problems we discovered were more on engaging the students in an ongoing conversation as in the studio-based experience. Loneliness due to a lack of opportunities to exchange ideas and get spontaneous and relevant feedback was the biggest challenge faced by this group of students. Despite the challenges, we observed that students were highly resilient in coping with finishing their projects.

The design students fall into the category of Gen-Z, who are highly capable of using technology, in a deep desire for work-life balance, in need of constant feedback, and prone to negative feedback as they are often considered as a failure (Stahl, 2019).

To engage this generation, the lecturers need to intentionally design a constant and regular feedback mechanism within the classroom as a part of the learning process. The feedback mechanism is not optional, but it is part of the assessment for those who give and receive feedback. In addition to the students, lecturers also need to design a weekly dedicated session in addition to their official classroom meetings only to give feedback to the students or a session where the design students basically can ask anything related to the topic of the week.

The proposed activities above are in line with the following learning outcomes (refer to the Table 1 above):

<table>
<thead>
<tr>
<th>Learning Outcome 4:</th>
<th>Able to present design projects through academic writing, posters, and verbal presentations.</th>
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<td>Learning Outcome 5:</td>
<td>Able to apply user-related theories to design projects, such as user experience design, personas, consumer journey mapping.</td>
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<tr>
<td>Learning Outcome 6:</td>
<td>Able to construct design concepts based on considerations of needs, technological feasibility, and environmental and responsible business considerations.</td>
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<tr>
<td>Learning Outcome 7:</td>
<td>Able to collaborate with various parties in managing design research.</td>
</tr>
</tbody>
</table>

3.4 Prototype

In a new normal situation, we need to change the way we think and operate our business. One of the learning
outcomes of the course is for the students to be able to implement design concepts into design alternatives. Prototyping is important evidence to show how the students transform user research data into design. Limitations, such as materials or tools to create the products are imminent, however, this situation should not stop the students to be creative in designing out-of-the-box solutions with innovative materials and approaches. Reverse engineering of the current solutions without clear expectations for innovation will only result in copying design solutions.

Our proposed solutions to consider the out-of-the-box solution as one of the aspects to assess. Pushing the students to explore a new area to find a specific solution is recommended. To improve a coffee product, Knapp, Zeratsky, and Kowitz (2016) looked for ideas and inspiration from anything outside of the coffee industry. Teaching methods and best practices of innovative and out-of-the-box prototyping will transform the current practice of prototyping activities.

The proposed activities above are in line with the following learning outcomes (refer to the Table 1 above):

<table>
<thead>
<tr>
<th>Learning Outcome 1</th>
<th>Able to implement design concepts into design alternatives.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Outcome 2</td>
<td>Able to visualize design alternatives using manual and digital media.</td>
</tr>
<tr>
<td>Learning Outcome 3</td>
<td>Able to apply design thinking principles in data collection, determination of design methods, and analyses required in formulating design concepts.</td>
</tr>
<tr>
<td>Learning Outcome 6</td>
<td>Able to construct design concepts based on considerations of needs, technological feasibility, and environmental and responsible business considerations.</td>
</tr>
</tbody>
</table>

3.5 Testing

Currently, many of the design students have not been able to test their prototypes because the testing of the prototypes requires tangible interaction and the students need to physically meet the target users to get their feedback.

However, none of us know how long we will be in the COVID-19 pandemic situation and thus we need to work on how to intervene in this situation, how to hack the process of testing the prototypes, so authentic testing experience can still exist.

One of our proposed activities is creating a 3D or 360 videos of the prototype and organising remote and online Usability Testing (moderated and unmoderated depending on the project). The other thing that we can experiment with is by sending cultural probes that consist of the miniature of the prototype with a pack of video or diary study to the target users so they can still have tangible interaction with the prototype in a unique way.

The proposed activities above are in line with the following learning outcomes (refer to the Table 1 above):

<table>
<thead>
<tr>
<th>Learning Outcome 4</th>
<th>Able to present design projects through academic writing, posters, and verbal presentations.</th>
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<tr>
<td>Learning Outcome 6</td>
<td>Able to construct design concepts based on considerations of needs, technological feasibility, and environmental and responsible business considerations.</td>
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<td>Learning Outcome 7</td>
<td>Able to collaborate with various parties in managing design research.</td>
</tr>
</tbody>
</table>

3.6 Release and Post Release
The Development Stage that consists of the Release and Post-Release steps of the Design Thinking 2.0 (Sari, 2020; Tedjasaputra and Sari, 2020) has not been explored yet in this course. However, this stage is a key stage when implementing Design Thinking in a real-world environment. This stage gives a sense of urgency and limitation of resources to get a product out of the line, which will financially benefit the stakeholders.

While Design Research courses emphasize a common Design Thinking approach, this course needs to be transformed to meet with the current industrial needs by adding the Development Stage as one of the components. The lecturers need to intentionally develop learning outcomes and activities to ensure students get the appropriate skills and assessed properly.

The proposed activities above are in line with the following learning outcomes (see Table 1):

<table>
<thead>
<tr>
<th>Learning Outcome 6</th>
<th>Able to construct design concepts based on considerations of needs, technological feasibility, and environmental and responsible business considerations.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Outcome 7</td>
<td>Able to collaborate with various parties in managing design research.</td>
</tr>
</tbody>
</table>

4. Conclusions and Future Works

The study has opened new ideas on how to run Design Thinking courses in a university during the global pandemic situation. The pandemic and its impact were unknown to all. Most of us have endeavored to find ways to make things work and give better results. This includes the education field as well.

This online Design Research course has a set of learning outcomes to equip students with key skills to run user experience design projects using the Design Thinking framework. During the first cohort, there were a lot of hiccups, which were mainly due to technology literacy, access, motivation, and external factors like access to target users, etc.

However, as the times progressed and learning online has become a norm in a new normal, the course needs to be leveraged and transformed. Using Design Thinking 2.0, which is an advanced Design Thinking framework developed by the second author, we conclude the following plans for the transformation of the Design Thinking courses (see Table 4).

These plans will be discussed further with other stakeholders who are part of the education system, but not part of this project to get approval for trials in the upcoming semesters.

| Table 4. Transformation Plan for the Design Thinking Course – Design Research |
|-----------------------------------------------|-------------------------------------------------|----------|
| Stages                          | Proposed Interventions                                | Learning Outcomes |
| Emphasize                      | ● Dedicated projects, contacts, and interviewees      | LO5, LO7   |
|                                | ● Group Project instead of Individual Project         |           |
|                                | ● Various Assessment Models: Differentiation, Individual, Peer and Group Assessments |           |
| Map and Define                 | ● Comprehensive scaffolding teaching and learning    | LO4, LO6   |
|                                | ● Personalized Mentoring Scheme: Industry Practitioners, and Peers |           |
| Ideate and Decide              | ● Comprehensive scaffolding teaching and learning    | LO4, LO5, LO6, LO7 |
|                                | ● Personalized Mentoring Scheme: Industry Practitioners, and Peers |           |
|                                | ● Intentional Feedback Mechanism: Practitioners,      |           |

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Lecturers, and Peers

Prototype
- Out-of-the-box Prototyping Methods and Process LO1, LO2, LO3, LO6

Test
- Remote, Online Usability Testing using Authentic Video LO4, LO6, LO7
- Sending Culture Probes with Prototype Miniature

Release
- Introducing the Development Stage of Design Thinking 2.0 that consists of Release and Post-Release in the Curriculum LO6, LO7

Post-Release

References


Design Thinking 2.0 for Curriculum Design and Development

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Abstract: This paper describes several identified gaps in Backward Design and how Design Thinking 2.0 may bridge the gaps. Never intended to be a silver bullet, Design Thinking 2.0 is a promising alternative to Backward Design that still requires further validation from more case studies.

Keywords: Curriculum Design and Development, Backward Design, Design Thinking 2.0, Design Thinking, Education, Wicked Problems

1. Curriculum Design and Development

As a process that requires high-order creative and critical thinking, curriculum design and development can be categorized as a wicked problem (Rittel, H. W., & Webber, M. M., 1973).


2. Backward Design


The main advantage of Backward Design is that teachers should be able to focus on teaching more effectively based on defined learning goals, while students should be able to focus on learning more effectively based on expected learning outcomes. In an ideal situation, every piece of instruction, resource, content, and assessment has a cohesive purpose towards the learning goals.

Despite its success in improving the effectiveness of teaching, Backward Design has several drawbacks as follows:

- Teachers communicate the learning goals to students and sometimes parents after the process of Backward Design has ended, and usually at the beginning of a lesson or course. When an extreme or sudden change in a situation that occurs during the lesson, like what we have experienced in the COVID-19 pandemic, there is no evidence or data to help teachers adjust their teaching.
- The premise of any successful Backward Design is the definition or identification of effective learning goals. Although teachers are provided with guiding questions in the three-stage process of Backward Design and guidelines related to the curriculum, such as a national curriculum, a failure in defining or identifying relevant and effective learning goals will catastrophically fail in the whole planning process.
- Backward Design is a teacher-centered framework that has no built-in mechanism to include student participation in the process of planning. In the three-stage process of Backward Design, a teacher is provided with several guiding questions to help them create content, resources, instruction, and assessment for the students, without student participation or feedback.
- There is no built-in litmus test to evaluate the outcome of the Backward Design process against the real needs of students.
- There is no built-in support or mechanism for planning personalised learning activities or differentiated instructional design based on evidence of student needs.

3. Design Thinking and Design Thinking 2.0

Design Thinking continues to expand its meaning and connections in contemporary culture (Buchanan, R., 1992). In this paper, we will use the following definition of Design Thinking: A non-linear iterative human-centred design process to solve wicked problems.

While Design Thinking has been around for about five decades (Simon, H. A., 1969), its application in curriculum planning is still in its infancy. Simon N. Leonard, Robert N. Fitzgerald & Geoffrey Riordan (2016) argues for the use of developmental evaluation as a design thinking tool for curriculum innovation in professional higher education. Willness, C., & Bruni-Bossio, V. (2017) introduces a Design Thinking framework of Curriculum Innovation Canvas that promotes a creative and fluid approach to curriculum development. Crites, K., & Rye, E. (2020) reports on the outcome of an exploratory case study based on the implementation of Design Thinking in a language curriculum design process at a Colombian university.

Design Thinking 2.0 (see Figure 1) (Sari, 2020) is an advanced version of the Design Thinking framework. In this framework, the design and development process is entwined with each other. The flexibility of iteration in each stage is an additional advantage in Design Thinking 2.0. Furthermore, time-boxing is another built-in property of Design Thinking 2.0 that supports creativity and people’s time to be involved in the process. The time-boxing is also the disadvantage of Design Thinking 2.0, in which a complex product that requires longer time to develop will not fit into this framework.

![Design Thinking 2.0](image)

*Figure 1. Design Thinking 2.0*

In relation to the design and development of curriculum, the Design Thinking 2.0 may provide an alternative to Backward Design. Similar to Backward Design, a teacher can use Design Thinking 2.0 as an integrated planning framework for designing assessment, content, resources, and instruction, and also bridge the gap posed by the Backward Design. Providing potential solutions to the gaps identified in the Backward Design, Design Thinking 2.0 has several advantages:
Teachers communicate the learning goals not only to students but also to parents before a planning process starts in Design Thinking 2.0. This event will provide an opportunity for both students and parents to provide feedback on the learning goals. If an extreme or sudden change in a situation occurs, like what we have experienced in COVID-19 pandemic, the teacher will be in a better position to adjust the learning goals based on prior feedback data and evidence from students and parents.

Due to the explicit and iterative process of identifying and mapping student needs, behaviour, attitude, pain, and gain in Design Thinking 2.0, the risk of identifying or defining false learning goals can be mitigated.

Nonetheless, when a failure is identified during a Design Thinking 2.0 process, it naturally occurs during the planning process, and not after the process has completed.

Once a failure is identified in the learning mechanism of Design Thinking 2.0, the teacher can then identify and rectify the problem based on data and evidence.

With a philosophy of designing for, with and by the students in a student-centred learning framework, Design Thinking 2.0 includes students in different roles throughout the process.

In Design Thinking 2.0, there is a built-in litmus test to evaluate the outcome of the Backward Design process against the real needs of students.

The use of Persona and Student Journey Map in Design Thinking 2.0 facilitates the development of relevant and effective plans for personalised learning activities and differentiated instructional design based on evidence of student needs.

Having outlined the advantages of using Design Thinking 2.0 compared to Backward Design, we have also identified some challenges posed by it:

- At least one facilitator is required in a Design Thinking 2.0 to help teachers in planning.
- The non-linear iterative nature of Design Thinking 2.0 implies that the process is more complex than Backward Design.
- The success of Design Thinking 2.0 relies heavily on the skills and experience of the facilitator.

4. Future Works

While Design Thinking and Design Thinking 2.0 applications in solving wicked problems in education are still emerging, in this paper we have presented the potential advantages of applying Design Thinking 2.0 in curriculum design and development. Nonetheless, as we need more data and evidence to support our thesis on the application of Design Thinking 2.0, we actively encourage and collaborate with the educational community to start identifying how Design Thinking 2.0 may benefit to solving wicked problems in education.

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A Study on the Characteristics of Cooperative Groups in Project-Based Learning of Advanced English

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Abstract: Advanced English is a compulsory course for undergraduates majoring in translation and interpreting, which is an extension of the course of intensive reading for junior students. It aims to cultivate students’ advanced abilities of listening, speaking, reading, and writing and translating, comprehensively improve their comprehensive language knowledge level and practical application ability, and gradually enhance students’ intercultural communication ability. Meanwhile it also deepens their understanding of society and life, and improves their humanistic quality. However, the wide materials, profound connotation, long sentences make students have difficulty in mastering this course, which further affects their interest in learning and frustrates their enthusiasm for learning. To a certain extent, it is not good at the teaching effect. The study has showed that cooperation study, compared with independent study, can guide students to study actively and create knowledge, this paper takes the course of “Advanced English” in Xi’an Fanyi University as an example. Through the interview of 15 students, it analyzes the cooperation group in the process of project-based learning so as to provide some lessons for undergraduate translation teaching experience.

Keywords: cooperative learning; Project-Based Learning; cooperative groups; Advanced English

1. Introduction

1980’s has witnessed cooperative learning become a commonly used form of active pedagogy, which continues to be a valuable tool for learning in academic institutions today (Johnson, Johnson, and Smith, 2007), as it provides benefits for both students and instructors (Shimazoe and Aldrich, 2010). Cooperative learning has been described by Slavin (1996) as teaching methods in which students can work together in small groups to help one another learn academic content. Johnson, Johnson, and Smith (1991) outlined several central elements comprising cooperative learning including positive interdependence, individual accountability, face-to-face promotive interaction, appropriate use of collaborative skills, and group processing, as will be discussed further. Studies on cooperative learning have indicated its positive relationship with student achievement and attitudes about learning (Slavin, 1989; Johnson and Johnson, 1989; Johnson et al., 2007). Cooperative learning has also been found to enhance social and intellectual development (Cohen, 1984; Burton, 1987) and help students build interpersonal skills while promoting a sense of achievement, productivity, and psychological well-being (Nilson, 1998). Further, researchers reported, “…students worked significantly harder for and learned more from the cooperative learning components than from the traditional lecture and text-based components” of courses studied (Carlsmith and Cooper, 2002).

Researchers and education specialists endorse the view that student learning can be maximized, thus academic performance improved, by developing a sense of “we are all in the same boat together,” a basic tenet of cooperative learning (CL). The effectiveness of CL principles and techniques in building a motivating, supportive learning environment is well known (Johnson and Johnson, 1989). As the benefits of collaboration in education are clear, the use of technology to facilitate CL is vital.

The CL model (Johnson and Johnson, 1989) incorporates five essential elements: positive
interdependence, individual accountability, face-to-face promotive interaction, social skills, and group processing. When these elements are structured carefully into the instructional format, improved student participation, motivation, and responsibility have been noted (Assinder, 1991). The student-centered approach of CL leads to learner autonomy. The positive impact of CL has far-reaching effects that extend beyond the classroom, into participants’ professional and personal lives.

Problem-based Learning (PBL) is a method of solving problems by students working together in groups. This learning method can help students to improve their ability to master basic knowledge and solve problems, cultivate their creative thinking, and improve their ability of independent learning and teamwork, which is an important way to realize the cultivation of innovative talents. 3 to 5 students are organized together to study the course according to the voluntary or coordinated way. Students and facilitators including teachers would form a harmonious, comfortable and unity of the academic atmosphere because of knowing each other, at the same time establishes the basic conditions for the cooperation study and discussion.

More and more researchers pay attention to the application of cooperative learning model. According to the research, compared with independent learning, cooperative learning can lead students to actively learn and create knowledge, improve students' learning performance and engagement in learning, and accomplish cross-cultural tasks. Advanced English is a compulsory course for undergraduates majoring in translation and interpreting. It is offered in the third grade as an extension of the intensive reading course for juniors. It aims to cultivate students' advanced abilities of listening, speaking, reading, writing and translating, comprehensively improving their comprehensive language knowledge level and practical application ability. It gradually enhances students' intercultural communication ability through the mastery of course content, which can deepen their understanding of society and life, and improve their humanistic quality.

However, due to the materials, profound connotation, long sentences with great difficulty, students have difficulty in mastering this course, which further affects their interest in learning and frustrates their enthusiasm for learning. To a certain extent, it is not good in the teaching effect. This paper takes the project-based teaching of Advanced English in Xi’an Fanyi University as an example. Through interviews with 15 students, this paper analyzes the characteristics of cooperative groups in the project-based learning process in order to provide some useful experience for undergraduate with major of translation and interpreting.

Cooperative group is a kind of learning organization, which advocates systematic thinking, self-transcendence, team learning, common vision and mental model, etc. Cooperative learning group refers to the one that teachers treat students in the classroom as the working groups having common learning tasks. The class itself is a cooperative study group. In order to promote the learning progress of students, teachers will divide students into different study groups or organizations. These study groups are also included in the scope of cooperative study groups. In cooperative learning group, teachers' management methods, methods and goals in class are all centered on students' learning, and students are the origin of classroom management mode of the cooperative learning group’s.

2. Method

2.1 Data collection

In this study, 15 students were selected as interview subjects majoring in translation and interpreting who participated in project-based learning of advanced English. This study adopts the semi-structured interview, mainly in the form of face-to-face interview. It takes about 1.5 hours of the average interview length of each interviewee with a total of about 60,000 words of interview materials. Before the interview, the author explains the intention of the interview to the interviewees and asks for their cooperation. After their agreement, interviewees are required to recall as many experiences or examples as possible when they participate in advanced English learning. Also, the author gives appropriate guidance and follow-up
questions according to the answers of the interviewees. At the same time; the whole interview process was recorded to ensure the accuracy and completeness of the interview materials.

(1) What is the common vision of the cooperative learning group of Projected-based Learning of Advanced English?
(2) What efforts have the students made to realize the common vision?
(3) What is the learning effect of project-based learning of advanced English?

2.2 Results

In order to test the reliability and validity of the code, this study adopts the method of coding comparison. In addition; this study has chosen 2 senior English teachers who have been engaged in the course of Advanced English for more than 5 years to complete the coding independently. Through the "code comparison", the consistency is between 0.891 and 0.805, with good reliability and validity. There are 21 initial categories, 9 main categories and 4 core genera.

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3. Discussion

3.1 Values of the Cooperative group

Students participated in the cooperative groups of Advanced English for the purpose of improving their abilities, cultivating their interests and achieving their own results. Many students study in high schools attached to foreign languages with a good learning foundation, so they hope to continue to develop their language skills and improve their ability in university (G11). Many students will learn more (G4, G8, G13), such as a more detailed understanding of English language (G9, G14), a more systematic culture of English-speaking countries (G8, G10, G11), and finally improve their ability (G9, G10, G11, G15) as one of the
personal expectations of advanced English project learning.

At the same time, competition is one of the important ways to test the effect of students' professional learning. In the interview, after learning this course, a student can participate in The English competition (G7) on behalf of the school, in which if he/she gets a good score in the competition (G13) he/she would get opportunities for his/her future employment, which is also the personal expectation of students to participate in project-based learning. On the basis of individual expectations, members in the group gradually get a common vision. By sorting out the interview materials, students all hope to get good grades in the project-based learning for their team and make the team become more and more outstanding (G13). They believe that what they do can contribute to the honor of the team (G15). Beside it, with the students to participate in cooperative learning further, students aims to improve personal power instead of doing a project well, and getting a good score (G8). Therefore, the students get less attention to the result, but more to the process (G9). Therefore, the common vision is team honor and individual growth for the members of cooperative group. In the process of the formation of the vision, members gradually tend to be consistent with each other from the individual's expectations and interests (G7, G10, G12, G13, G15) after the ongoing discussion (G9, G10). During this process, the common vision is slowly formed after the compromise of members (G4, G15), which was approved by most people (G10, G12, G15).

After the formation of the common vision, the long-term learning is affected by subjective and objective factors such as ability, knowledge level and teamwork, which would make the common vision often change more or less (G4). At the beginning of the common vision, everyone have confidence in themselves (G11, G15), which would make them assured (G10) and do the very high and ideal (G11) common goal. Along with the advancement of learning and training, the common goal will become more clear (G10, G13), because of the gradual understanding of themselves and the team's ability (G11, G14). After the profound understanding to their own advantages and disadvantages (G13), they would reduce and adjust the common goal, which would be close to the team's real ability level (G10, G13) through mutual understanding, compromise, and running-in (G14).

3.2 Management mode

In the cooperative learning group of Advanced English, students are divided into leaders, creatives, implementers, learners, etc. (G14, G15). Each participant starts from the part he/she is good at, performs his/her own duties, and makes joint efforts for the success of the team, without causing chaos to the team (G9, G10). In practice, the role of students participating in cooperative learning groups is often flexible. When there are problems in learning, the members may be learners to learn to make up for the deficiency. When they are familiar with the problems they encounter, the members will become the imitator of knowledge to tell everyone what they know (G11). There is no permanent role in cooperative learning groups. Each person will become a leader in his or her own area of expertise, and a learner in others' area of expertise (G10). It can be said that in cooperative learning groups, there is no strict boundary for the division of student roles, and everyone can be a role of every kind (G15). Students in cooperative learning groups admire those who have clear thinking (G9, G10, G13, G14), especially stable production structure or design program (G13, G14), the strongest strength in all aspects (G7, G10, G13), strong executive ability (G4, G8, G11) and can coordinate the team (G7, G9, G13, G15).

In cooperative learning group, the teacher's role cannot be ignored. Students consider that teachers play a controlling and leading role in groups. During interviews, middle school students will compare teachers to "baby-mother" (G4) and "catalyst" (G13), supervise students in learning and training (G4), guide students in training to conquer difficulties and avoid detour (G13). Students believe that teachers will be more comprehensive than students in thinking and leading the way in training (G10). At the beginning, since many students had not participated in project-based learning before, teachers undertook the task of enlightening (G8, G11) and teaching students some basic knowledge (G10, G11, G14). In addition, cooperative learning group of students encountered many difficulties, such as sidetracking in some of the problems (G4, G10), at this time, the teacher can play a bigger role on the key issues for some students (G4, G10) or inform the students to give up (G4), in a way of thinking or viewing difficulties (G10), helping
In addition, in the analysis of the interview data, we found that, in the eyes of students, teachers are also another role as the resource providers (G4, G10, G15). In the training, the teacher should provide students such as study materials (G13, G4), intercollegiate exchange (G9, G13, G14), competition show (G9, G15), etc, to help students to learn better.

3.3 Learning methods

In the course of project-based learning, cooperative group is inseparable from the acquisition, preservation and sharing of learning materials. Through the analysis of the interview data, we found from the source of learning material, students are learning how to deal with similar problems (G9, G11) mainly according to the network video and strategy (G8, G9, G11). They can find the way of thinking from their solution to the problems from which they encounter (G8, G9, G11).

For a wide variety of network resources, new students are not good to identify the network resources that often get help for reference blindly (G10, G13). The experienced students will give more remind and guidance (G8, G11), to help novice with clear details, identification and study materials (G13). In addition to helping to identify and search learning materials, the students would accumulate more experience over a long period of time. Every year, members of the group participating in the project will communicate and instruct with experienced students in the daily learning and training (G11, G15), and then "teach" their own experience to the best of their ability (G11).

The team would to save the own successful application and the case (G9, G11, G12, G13), which they would seldom use in the future. But the learners think that these projects are all the difficulties they have overcome which would become new knowledge to be saved (G9, G12). Through completed projects, the cooperative group has established its own technical "database", which is convenient for timely inquiry and use in future projects and can shorten the completion time of the project (G13).

As mentioned above, teachers provide opportunities for the learning group to communicate with students from other schools. During the communication, members of the cooperative learning group will use their problem-solving methods (G9) for reference in the communication with students from other schools, and incorporate these advanced experiences into their own "database" (G4). Therefore, it can be said that to gain experience and draw advantages from the outside world (mainly other schools) (G4, G10), and become important learning materials for their own cooperative learning group.

In the analysis of research materials, we found that in cooperative learning groups, besides the clear division of learning mentioned above, learning and sharing around learning materials are also very important learning activities. Around learning materials, members of cooperative learning groups often take steps of imitation, understanding, thinking and modification (G4, G15, G11) to gradually internalize them into their own knowledge and skills. In the analysis of the interview materials, we found that learners would actively and subconsciously share the good learning materials they met in the completion of the project (G4, G10), and organize their peers to analyze and discuss the learning materials (G10, G13). We analyze the learning materials together to find the direct correlation or similarity with the team's ongoing project (G13, G14), to help the team to better complete the project.

3.4 Achievements in learning

After participating in the cooperative study group, students realize that their operational ability has been improved (G15) and their thinking more logically (G15, G10, G8). In the process of completing the project, the students expressed that they gradually learned to break down the problems they encountered, and then they would try and improve continuously, and finally solve the problems (G10). By participating in the study, students showed that they were better at communication and expression, able to share and communicate with people around them, and deal with the relationship with people around them (G15). They were more willing to communicate with others (G10). Students have changed from being introverted to being more willing to communicate with others (G4), and they are not as shy or nervous as before with
their social skills improved (G10, G13, G15).

Through the analysis of the interview materials, we find that in terms of study habits, students feel great about learning new things all the time by participating in cooperative study groups (G8). They find that they can keep learning and know what they want to learn so as to work hard for it (G14). Through the analysis and coding of the interview data, it can be seen that after participating in the cooperative learning group, students have improved their abilities such as hands-on practice, knowledge application, communication and sharing.

4. Conclusion

4.1 The relationship between common vision and personal expectation

In the group, it is important to establish the common vision, so that students have the power of unity. When members of the group have a real common vision, it can hold the group together. In the learning process of Advanced English learning in which the scores are as the main evaluation goal to achieve excellent results. In the establishment of the common vision, attention should be paid to the mechanism of the common vision formed by the convergence of students' personal expectations, and the common vision should be gradually formed based on the personal growth and interest cultivation of students' expectations. It is essential to avoid simply positioning achievement of score as the common vision. Attention should be paid to the growth of students to avoid utilitarianism.

4.2 Member structures of diverse roles

According to the creative theory of complex systems, diversity and the relationship between diversity is an important condition for the creation of systems. The cooperative learning group has the roles of leader, instructor, learner and coordinator, etc. In practice, students should choose various roles independently according to their abilities, so that students can give full play to their strengths and improve their abilities in the role. As a member of cooperative learning groups, teachers should be good supporters to provide knowledge support for students. Teachers should provide necessary knowledge support through projects and questions and emotions. Teachers should also support students to build flexible, diverse, equal and easy team structure in the cooperative learning group, encouraging students to express different views, and complete the learning task; Teachers should also provide opportunities for students to communicate and learn from each other and reflect on their progress in study.

4.3 The practice of learning method

Although there are a lot of advanced English textbooks and materials in the market, they are often difficult to adapt to the actual situation of the school. From the previous analysis, it can be seen that in practice, cooperative learning groups will start from problems, consult network materials in a targeted way, and form their own materials through reference, imitation and improvement. In addition, students will save successful attempts or reflections as learning materials to form their own "database". Therefore, in practice, we should guide students to pay attention to the selection and accumulation of materials, to form learning materials with the school's own characteristics, and school-based teaching materials. In terms of the organization of learning activities, students should be guided to carry out more metacognitive activities, summarize experience in identification and reflection, and continue to learn to improve their abilities.

References


A Study on the Flipped Classroom Application in Vocational Training

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Abstract: Flipped classroom is a new teaching mode by the influence of information technology application, and videos provided by teachers work as the main form of learning resource. Therefore, students need to complete teaching videos and other related learning resources before class, and then both teachers and students focus on completing homework, Q&A, collaborative inquiry and interactive activities in classroom. From recent researches of the flipped classroom, the basic process of teaching is that students are required to read learning materials and resources – do classroom exercises – teacher gives guidance - summary. When the flipped classroom is applied in vocational training, there are issues to be considered and resolved, such as how to present knowledge, ability and value through “video”; how to reasonably allocate and effectively integrate in-class time and after-class time in training; how to connect physical classroom with network classroom; how to overcome the limitations of reliability and validity of the training content, mode and evaluation. The article mainly focuses on four aspects of the Flipped classroom: What flipped classroom is; the role and effect of flipped classroom; How to implement the flipped classroom in vocational training and adult education; the restrictions and challenges of implementing the flipped Classroom. The main findings are that Flipped classroom is an effect way for vocational training. It is suitable for adults and puts forward higher requirement for instructors and learners.

Keywords: Flipped Classroom, Blended learning, Vocational training, Training process

1. Introduction

The continuous development of information technology promotes the process of education reform and the teaching and learning capability. The deep integration of information technology and education is to identify an effective way to realize the educational informatization, in order to highlight the significant effect of information technology application in the field of education. However, the integration is not just gradual repair of teacher’s teaching method, and it is mainly for the structural change of education system. In the past ten years, information technology and education were difficult to involved in deep integration, and the application of information technology in education were usually located in the instrumental level of assisting teaching procedure or partly supporting students’ learning, without touching the essence of education or promoting students' personal growth. The flipped classroom provides the possibility for the deep integration of information technology and education.

The flipped classroom is an instructional strategy and a type of blended learning that reverses the traditional education arrangement by delivering instructional content, often online and outside of classroom. It transfers activities, including those may have been traditionally considered homework, into the physical classroom. In a flipped classroom environment, students firstly watch online lectures, collaborate in online discussions, or carry out research at home and engage in concepts in the classroom with the guidance of the instructor.

Jonathan Bergmann and Aaron Sams, the chemistry teachers from Woodland Park High School, became driving forces in flipped classroom teaching at the high school level. In 2007, they recorded their lectures and posted them online in order to provide help to students who missed their classes. Bergmann and Sams noted that a lot of conceptual knowledge or operating methods did not need to be taught in class, and learners could study according to their own individual experiences. Furthermore, they asserted that there was no one ‘right’ way to flip a classroom as approaches and the teaching styles needed at schools
were diverse. If the classroom teaching and knowledge internalization out of classroom are flipped, the new teaching structure of "learning outside the classroom, internalizing knowledge in the classroom" will be formed, and also the study will become more effective. In 2011, Salman Khan introduced a new teaching method, the flipped Classroom, to the world at the TED conference. Soon afterwards, the flipped Classroom became the global focus teaching mode in the field of education. At present, more and more schools are applying the flipped classroom to teaching practices, and they have already achieved good teaching effects.

2. The Concept of the Flipped Classroom

The Flipped Classroom is a new type of teaching mode in the informational Technology environment. In this mode, teachers provide teaching videos as the main form of learning resources, then students complete the tasks of watching and learning the video resources before class, afterwards both teachers and students finish homework, Q&A, collaborative inquiries and interactive communication activities in classroom together. Many researchers have conducted a series of researches about it. The main definition is elaborated from the view of its implementation process and the concept of its learning essence, and the definition from learning process can be roughly divided into two stages: knowledge instruction and knowledge internalization. The Flipped Classroom aims to reverse the two stages, and the method is: before class, students are required to complete the knowledge imparting by watching teaching videos; in class, students need to complete the internalization of knowledge through a variety of teaching forms, such as group discussion, homework and teachers’ individual support. However, it does not give explicit information to the practitioners with the judgment standard for the flipped classroom. For example, if students firstly complete their self-studies before class, and then finish the discussions in class, can it be called a flipped classroom? Obviously, it is not the case. In the flipped classroom, only the teachers’ teaching effect of imparting knowledge before class reach or even surpass the effect of traditional transferring teaching in classroom, which can be regarded as the completion of imparting knowledge, then the students can enter the stage of knowledge internalization.

Teaching video is not the focus of the flipped classroom. The subversion of the traditional teaching process and student-centered conception are the real meanings of the flipped classroom. The influence is not only the innovation of teaching method, but also the reversion of traditional teaching structure and methods by setting up a relatively thorough "student-centered" teaching mode. In this mode, teachers will become the organizers, facilitators and guides of students’ learning.

Technology development realizes the concept of “learning before teaching” and improves its implementation. Based on the man-machine interaction technology, the flipped classroom can collect the data of student's learning process and behavior. Effective information of students’ personalities, behaviors and abilities can be obtained through data mining, in order to provide empirical data for teachers’ teaching diagnosis, summary and improvement.

From the existing researches and practices of the flipped classroom, the basic process of teaching is: students are required to read learning materials and resources - classroom exercises - teacher’s guidance - summary and promotion. Compared with traditional classroom process "preview - lectures - practice", it has great differences in instructional design and teaching organization. The differences are shown in table 1.

Table 1. The Differences between the Flipped Classroom and the Traditional Classroom

<table>
<thead>
<tr>
<th></th>
<th>Traditional Classroom</th>
<th>The Flipped Classroom</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teachers’ Role</strong></td>
<td>Transmitting wisdom and imparting knowledge</td>
<td>Coach, Mentor, Facilitator</td>
</tr>
<tr>
<td><strong>Learner</strong></td>
<td>Passive listener and receiver</td>
<td>Active participant</td>
</tr>
<tr>
<td><strong>Instructional Mode</strong></td>
<td>Training lectures + Homework after class</td>
<td>Learning before class + In-class inquiry</td>
</tr>
<tr>
<td><strong>Learning Content</strong></td>
<td>Imparting knowledge</td>
<td>Q&amp;A, discussion</td>
</tr>
<tr>
<td><strong>Technology Application</strong></td>
<td>Tools mainly for content</td>
<td>Tools for self-study, communication,</td>
</tr>
</tbody>
</table>
3. The Application in Vocational Training

The main object of vocational training is adult, whose learning are recognized as independent and explorative, and not applicable to use the traditional cramming interpretation. Adult learning should be given the priority to self-study. Students prefer learning basic theories outside class and conduct cooperative activities, such as in-class discussion, for better development. The Flipped classroom is completely in line with the teaching concept above, at the same time it also provides the operation scheme and procedure, and thus has good application prospect for vocational training. With the development of open online education, such as MOOCs (Massive Open Online Courses), teachers can use the curriculum resources (including teaching video) as their teaching basis in the future, and even their teaching work can be completed by referring to the teaching videos. In that case, teachers only need to play the roles of mentors and organizers of communication activities, which will have a deep impact on teachers’ roles and their divisions of labor.

The flipped classroom requires training lecturers to become the organizers, facilitators and guides of students’ learning. In the past, the time allocation between interactive discussion and teaching knowledge was 20%:80%, but now it turns to 30%:70%. And the interactive discussion time has increases from 20% to 70%, which requires training instructors to do well in learning program design and rigorous teaching logic design, and also requires employees to learn and be well prepared for class discussion with the questions in advance. However, it is difficult to ensure trainees to complete all the tasks by themselves in vocational training, so trainers need to build learning resources to enhance the training capacity and improve the ability for better control the process of the flipped classroom.

The Flipped Classroom application in vocational training can be divided into three steps, as shown in table 2.

Table 2. Three Steps of the Flipped Classroom Application in Vocational Training

<table>
<thead>
<tr>
<th>Training Steps</th>
<th>Training Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Self-Study</td>
<td>Before the trainees participate in formal classroom training, students are required to learn basic theory knowledge and skills, complete self-study and evaluation in advance through e-learning platform, knowledge manuals, textbooks and other teaching means</td>
</tr>
<tr>
<td>2. Face-to-Face Training and Learning Experience</td>
<td>Trainees attend face-to-face training with questions. Trainers reduce the time of knowledge imparting; spend more time in case discussion, scene simulation, question &amp; answer, and action learning; encourage students to participate. It helps employees combine theoretical knowledge with daily work practice for reflection and learning experience, and step into a higher cognition stage. The effect of classroom training has also been fully developed.</td>
</tr>
<tr>
<td>3. Practice after Class</td>
<td>After class, staffs need to complete the follow-up review and study using e-learning or cell phone tools, which helps employees convert the short-term training into long-term persistent learning. Training brings further promotion and greater work support for employees.</td>
</tr>
</tbody>
</table>

By now, more and more enterprises have gradually realized the values of vocational training. The value that “training is mainly for knowledge popularization and professional quality improvement” is changing, and at present vocational training is not only focusing on the required knowledge and skills according to the current job settings, but also turning to pursuit what problems can be solved by training. An attempt of combining training methods "going out", "bringing in" and "do-it-yourself" becomes popular. So trainers can change the original business knowledge imparting, and pay more attention to the practical
training. The flipped classroom is a new thing, when applied in the enterprise training, and there are four key issues to be considered and resolved:

- How to use "video" to vividly present knowledge, skills and values.
- How to reasonably allocate and effectively join the inside and outside training class time.
- How to effectively connect face-to-face training classes with online classes.
- How to overcome the limitations of the reliability and validity of the training content, methods and evaluation.

4. The Effect of the Flipped Classroom

4.1 The Flipped Classroom Can Reflect Advantages of the "Blended Learning"

The flipped classroom can not only increase the interaction between teachers and students as a means of personalized learning, but also provide a kind of brand-new blended-learning mode. In fact, from the beginning, the flipped classroom mixed two ways of learning - watching teachers’ videos before class and doing homework or experiment under the guidance of teachers after class. Later, the flipped classroom absorbed the characteristics and strengths of MOOCs, and further developed into the mode of blending open online courses and classroom teaching. The flipped classroom emphasizes the interactions between teachers and students, the interactions among students, and self-learning and collaboration based on problems and resources. It is the achievements of reform implementation in classroom teaching mode guided by the "Blended Learning" education thought.

4.2 The Flipped Classroom Accords with the Cognitive Rules

In the 2011 INTEL digital learning annual meeting, Brian Gonzalez, the director of INTEL global education, said “The flipped classroom makes educators give students more freedom, puts the process of knowledge outside the classroom, lets the students choose the most suitable way to accept the new knowledge, whereas put the knowledge internalization process in classroom, so that gives more time for more communication and exchange between classmates, between students and teachers.” This is a representative viewpoint to analyze the function and effect of the flipped classroom in terms of the human cognitive rules. This view has been responded by many scholars from China. For instance, Professor Tian Aili from East China normal university said “The flipped classroom is more in line with students’ learning rules. It is a form of learning before teaching. Compared with general guidance in the form of learning before teaching, micro video learning is livelier and video learning can replace teachers’ knowledge teaching. Students most need teachers’ help, while students encounter difficulties and confusion, during doing homework. And the flipped classroom can achieve this point.”

4.3 The Flipped Classroom Is More Learner-Centered

In traditional face-to-face teaching process, both the teacher’s teaching and the student’s dialogue are in the one-to-many “teacher-centered” form. The flipped classroom changes the form of class completely: whether students watch teaching videos at home, or teachers and students interact face-to-face in the classroom, the teaching activities will always revolve students. Students can control their own video learning schedules, put forward their own problems and ideas, and communicate with teachers or peers, so as to gain the initiative in learning. Teachers change their roles from knowledge teaching instructors and classroom controllers in traditional classrooms to the developers of teaching resources, learning mentors and facilitators. At the same time students change their roles from passive recipients into active researchers. Besides, some scholars emphasize that the flipped classroom gives students more discretionary time through the reallocation of learning time, so that the students can control their studies according to their own paces. It truly achieves the return of students learning, and reflects the subjectivity of students learning.
4.4 The Flipped Classroom Can Promote the Effective Use and R&D of Teaching Resources

With the rise of "MOOCs", the flipped classroom absorbs the advantages and features of open online courses. Teachers pay special attention to the extensive collection, effective utilization, deep research and efficient development of online teaching related resources, and also the academia generally believes that the flipped classroom is very beneficial to promote the effective utilization, research and development of teaching resources. It is not only the ideal platform to promote the utilization of teaching resources, but also a powerful force to promote the further research and development of teaching resources. In the flipped classroom, the contents of a lesson are further refined into several knowledge points. For each knowledge point, the flipped classroom uses a "micro video" to explain knowledge, and equips with specific corresponding exercises to consolidate knowledge. The length of micro video is generally from 5 to 10 minutes.

5. The Restrictions and Challenges of Implementing the Flipped Classroom

5.1 The Research and Development of High Quality Teaching Resources for Various Subjects

The Flipped Classroom requires learners to watch some illustrative materials from their teachers before class. At the early stage, those materials were recorded in the traditional ways of “teaching videos”, and subsequently, they were developed into “micro videos” equipped with a series of separated “Knowledge Points” combining their targeted practices. As a matter of fact, there are significant differences for each subject in teaching content, knowledge architecture and knowledge point packet. Thus in order to promote the Flipped Classroom which has been recognized as a brand new teaching mode in multiple subjects and strive to achieve its "normalization", the demand scale of micro videos and learning resources is estimated to be huge. With the support of nonprofit Khan Academy, the United States can solve the problems in the research and development of high quality teaching resources for various subjects, however, there is still lack of local NGOs similar to the "Khan" in China, so there are still many grim challenges in this aspect.

5.2 Instructors' Educational Thought and Conception Need Update Urgently

The flipped classroom is based on "blended" learning mode, and its teaching process includes two sections before class, which are e-learning and face-to-face classroom teaching. The former one is characterized with independent self-study by learners, but instructors' inspiration, support or guidance should not be neglected; on the other hand, the latter one focuses on the guiding roles of instructors, what’s more, it pays great attention to the learners on how to promote the internalization of cognition and emotion through independent study and group cooperation and exchange under the guidance of instructors. Obviously, in order to carry out these two parts of teaching and realize scheduled teaching goals effectively, instructors' educational thought and conception need to be updated. Instructors should set up their educational thoughts as neither "instructor centered", nor "learner centered ", but be marked with the Blended-Learning thought which combines the advantages of e-learning and traditional teaching and learning methods. Therefore, it is necessary for instructors to make their roles as not only inspiration, guidance, or monitoring, but also fully reflect the initiative and creative matters of learners during the process of learning.

5.3 The Flipped Classroom Puts Forward Higher Requirements for Instructors

In order to achieve the extracurricular self-directed learning goal, instructors should construct a completed learning support system in advance, regardless of importing and pretesting knowledge points, or organizing of learning resources, study carefully, and build a virtual learning environment for suitable self-directed learning and accessing learning resources conveniently. On one hand, it is essential to guarantee learners to conveniently access to learning resources in the process; on the other hand, setting up some incentive measures and guiding means to stimulate learner's intrinsic motivation is also acceptable.

Because the flipped classroom has changed the "classroom" into the stages of "knowledge deepening and internalization", learners from different levels can make full use of their advantages and
expertise, and achieve improvements by "reporting", "questioning" and "debating" in class. Therefore, in this process, instructors should be given full play to their own duties, and also be given really guide, manage and control during the process of discussion. And this can play the "finishing touch" role in critical moments, which actually impels the deepening of learner's learning.

5.4 The Flipped Classroom Puts Forward Higher Requirements for Learners

Firstly, the Flipped Classroom requires learners to have their own abilities of independent study. Secondly, because the mainstream learning support systems run in the Internet environment, learners need digital terminals to access learning support systems. Therefore, learners have to master certain IT knowledge and skills before easily accessing learning support systems and teaching resources, and complete extracurricular self-directed learning. Thirdly, it is necessary for learners to pay more efforts to in-depth thinking during the teaching based on the flipped classroom, and students need to spend more time and energy on each class. Fourthly, traditional teaching mode is still an effective and quick means of transferring knowledge for the students who have weak foundation and especially are lack of self-directed learning abilities.

Acknowledgements

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References


Exploring the Strategies for ICT Integration with School-based Professional Development: A Case of a Mainland Chinese Primary School

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Abstract: Based on a collective case study of three groups of teachers from Chinese, English and Mathematics specializations from a primary school in South-western China, this paper aims to evidence the strategies for ICT integrated with school-based professional development for primary school teachers. According to the research results, this study provides practical suggestions from three perspectives: resource application, ICT tool application and school-based professional training.

Keywords: New basic education; ICT integration; primary school teachers; professional development

1. Introduction

According to the overall deployment of the "Education Informatization 2.0 Action Plans" and "Teacher Education Revitalization Action Plan (2018-2022)" , the Ministry of Education of China has decided to promote the integration and innovation of information technology in education. Educating teachers on how to use ICT to enhance their teaching practices is an important objective of teacher education (Chang et al., 2012; Tondeur et al., 2017). The project of "New Basic Education" was an experimental project for basic education reform, aiming at creating modern Chinese schools to "cultivate life consciousness, develop people and make achievement" (Ye, 2015). In recent decades, this project has been deduced, summarized and refined into a series of educational theories based on the reality of Chinese Local Education - "Life-Practice School of Educology". In March 2017, Zhuoran Primary School officially joined the project "New Basic Education". As a sampled school, Zhuoran Primary School has made great efforts on building their teachers’ ICT-related competencies and encouraged teachers to rethink, redesign and reflect their subject teaching and learning with the support of ICT. Therefore, this study investigates the strategies for ICT integration with the school-based professional development of primary school teachers.

2. Literature Review

Teacher professional development is a life-long and continuous process, in which teachers are expected to upgrade their knowledge, master new skills and change their practices (Santos & Miguel, 2019). The improvement of their teaching career is finally for their students and education reform (Dwivedi & Alam, 2011). Teachers’ professional development is related to the success or failure of school development, and it also leads the reform and development of teacher education. In recent decades, the large-scale introduction of ICT into classroom has become an important way to affect the professional development and growth of teachers (Liu & Li, 2019). As shown in Figure 1, in the practice of "New Basic Education", teachers’ professional development is realized through "Research-oriented reforming practice". Based on the "New Basic Education" theory, the practice of school research-based change is formed by the change of daily education and educational practice. In the practice of "New Basic Education", every teacher who
participates in the practice of research-based change is required to become an independent reform practitioner with theoretical guidance (Zhang & Ye, 2014). The research-oriented reform practice emphasizes the value and significance of teachers' daily educational practice for their own development (Zhong, 2017). With the guidance of educational experts, teachers constantly reflected and reconstructed, and constantly summarized the accumulation of daily experience to promote the professional development of teachers. The reform of educational theory and teachers' educational practice is a complex relationship of mutual construction and transformation, which not only puts forward new requirements for teacher development, but also provides opportunities and space for teachers' professional development (Feeney, 2016).

Figure 1. The realization of teachers’ professional development through the research-oriented reforming practice

3. Methodology

To fulfill the aims of the present study, a purposive sampling method was adopted. Both qualitative and quantitative research methods were employed. A total of 80 teachers from specializations of Chinese 35, Mathematics 25, and English 20 were chosen for this study. This study lasted for four semesters. Data were collected from interviews, students’ questionnaires, teachers' feedback and reflections, teachers’ records, and etc. The qualitative data analyses were mainly through Coding, while quantitative data were analyzed by SPSS 20.0.

4. Profiles of three cases

4.1 Profile of case one: ICT integration with Chinese teachers’ professional development

In 2012, the Zhuoran Chinese team set up a national school-based Chinese curriculum system, developed national school-based teaching materials and continuously revised them in teaching and learning. Meanwhile, the Chinese team made use of the advantages of ICT to optimize Chinese teaching in the school.

4.1.1 Recording micro-lessons

In 2020, thirty-one Chinese teachers recorded micro-lessons during the postponement of the start of the new pneumonia epidemic. Through online lesson preparation, there were three sections in micro-class teaching: Recitation and Rehearsal Hall, aid-learning Magic Bag and Challenge, guiding students to "read,
think, understand and practice”, and learning Chinese with interest. During the 12-week network teaching period, the Chinese teachers studied the teaching materials, overcame the difficulty of being not familiar with the technologies, and recorded 63 micro-lessons of Chinese learning.

4.1.2 Constructing the online-learning platform

In the spring of 2020, with the "learning together" APP, an online-learning platform was built to provide rich materials for learning Chinese classics. Chinese teachers organized students to punch in their cards, read aloud and recite ancient poems on the online-learning platform, and carry out activities, such as online exchange, discussion, and digital Chinese classics stories. Till the end of spring semester, Chinese teachers had organized 474 exchange activities in 45 classes. As shown in Table 1, totally 1787 students, about 95.77% of students in Zhuoran, had participated in Chinese online learning.

Table 1. Students' Chinese online-learning outcomes

<table>
<thead>
<tr>
<th>Total number of students</th>
<th>Online self-learning</th>
<th>Online self-learning with parents' help</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>number of students</td>
<td>%</td>
</tr>
<tr>
<td>1866</td>
<td>1787</td>
<td>95.77</td>
</tr>
</tbody>
</table>

4.1.3 Chinese teachers’ awards

Zhuoran Chinese teachers’ professional learning has been developed rapidly with the ICT-supported instructional environment, especially in terms of curriculum development and teaching implementation. Chinese teachers have won various awards in City-level teaching and research achievements in Guilin Basic Education (See Table 2). Especially, Chinese teacher, Miss Tang Xili won the national "Model Teacher" title, and Miss Mo Nini won the "Excellent Teacher" title in Guangxi Province respectively.

Table 2. Awards for Zhuoran Chinese teachers (Jan.2019 - Jul.2020)

<table>
<thead>
<tr>
<th>Team Research Project</th>
<th>City level research projects 2019</th>
<th>City level research projects 2020</th>
<th>City level achievements in education</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>One for Level A</td>
<td>One for Level B</td>
<td>One for First Prize</td>
</tr>
<tr>
<td>Individual Research Project</td>
<td>Honorary</td>
<td>Classroom Teaching Competition Award</td>
<td>Paper Publication Award</td>
</tr>
<tr>
<td>No.</td>
<td>22</td>
<td>17</td>
<td>45</td>
</tr>
</tbody>
</table>

4.2 Profile of case two: ICT integration with Mathematics teachers' professional development

In order to improve Mathematics teachers' ability to use ICT in their teaching and learning, they employed Linglong Drawing Board, Hao Jun dynamic Mathematics and mathematics Class Stack to improve mathematics teaching quality. Furthermore, a comparative survey was conducted in 2019 and 2020 respectively to make contrast for the implementation of ICT integrated into mathematics teaching. we conducted a survey on the allocation of teachers’ lesson preparation time among 20 mathematics teachers respectively (See Figure 2 & 3). After mastering the visual technology, the distribution of mathematics teachers’ lesson preparation time changed significantly. Teachers' lesson preparation form was simplified, which saved a lot of time in preparing teaching AIDS, and teachers had more time to focus on students themselves. The value of visual teaching design lies in that every teacher becomes a designer, fully displays the vitality of classroom teaching.

Mathematics teachers regarded the ICT integration as the foothold for professional development,
and made the following main achievements: Firstly, Mathematics teachers successfully applied for the municipal project "Research on visualization Design and Application of Key and Difficult Knowledge in Primary School Mathematics" in 2018, and successfully closed the project in 2020. Secondly, Mathematics teachers collected more than 50 mathematics research samples and wrote more than 100 teachers’ self-reflections on teaching and learning and working summaries. Last, Mathematics teachers had 11 papers published in provincial journals, and 2 papers won the first prize in the municipal paper competitions.

Figure 2. The distribution of Mathematics teachers' preparation time in 2019

Figure 3. The distribution of Mathematics teachers' preparation time in 2020

4.3 Profile of case three: ICT integration with English teachers' professional development

The network technology has brought new development opportunities and challenges for Zhuoran English teachers to continuously explore new teaching methods. In the past three years, Zhuoran English teachers have combined new basic theories with multimedia software, such as Homework Network, Fun Dubbing, WeChat, Youdao, Himalaya and other Apps, to carry out "Cloud teaching and research" and "Cloud coaching" to promote professional development.

4.3.1 Build up a learning community to promote professional learning

As shown in Figure 4, in terms of paper publication, lecture sharing, teaching experience and classroom teaching, English teachers' theoretical materialized achievements and teaching practice cases have changed qualitatively, teachers' self-professional identity has also become higher and higher. English teachers' team has developed a strong sense of independent development, a good communication and cooperative learning
community. Meanwhile, with the support of "Smart Cloud Platform", English teachers jointly created learning and teaching resources. They can think and innovate on a certain knowledge hotspot. New ideas and new thoughts can be recorded to create richer and more diversified teaching resources. Teachers can download the necessary resources from the resource library, or watch videos for learning, and then reflect on and reconstruct on their own teaching practice. English teachers learning community is still in innovation and change, teachers also need more interactions to obtain teaching knowledge and to greatly improve the teaching ability and research level.

Figure 4. The professional growth of English teachers

4.3.2 Multi-dimensional investigation of classroom teaching

In the end of 2019, a survey was conducted among all English teachers with the status of teachers and students as the core. A total of 38 questionnaires were distributed and collected. Figure 5 shows that in practice, teachers actively "give up" and give time to students instead of the whole class. In the class teaching, teachers increased students' individual learning, group learning, group learning, large group discussion, teaching or scene performance and other activities or organization methods, and gave back the learning space to students. Meanwhile, teachers should pay attention to the combination of content and methods. Teachers no longer regarded questioning as their own privilege, but encouraged students to preview and think independently. Teacher also put forward questions of various types, including questioning, putting forward different views from teachers, classmates or teaching materials. Teachers actively returned the right of evaluation to students, allowing students to self-evaluate or evaluate others; express their feedback, put forward opinions, praise and suggestions. Teachers presented a variety of resources in "Multi-dimensional interaction" and promote “interactive feedback” as well.

Figure 5. Self-evaluation for the interactions between teachers and students
5. Discussion and conclusion

Zhuoran Primary School explores the in-depth ICT integration of teaching Chinese, mathematics, English and other disciplines, to improve teachers' ICT competencies, innovation ability, self-awareness of professional development, and self-learning and reflection ability. Therefore, Zhuoran Primary School had summarized the following three strategies for teachers' professional development supported by ICT.

5.1 The network information resources

The application of the network information resources can encourage teachers to broaden their horizons, to learn advanced educational concepts, to understand the educational development trends. Furthermore, with the help of ICT-supported teaching resources, teachers have paid more attention to realize the deficiencies of their theoretical knowledge and teaching methods, to stimulate their professional learning, and even to strengthen their awareness of professional development.

5.2 The application of ICT tools

The application of ICT tools can make our classroom more vivid, so as to improve the efficiency of classroom teaching. Making good use of ICT tools can not only promote the communication and exchange between teachers and students, but it also can accumulate rich practical experience for instructional work, and finally can realize the growth and development of teachers' professional development.

5.3 The school-based research and training activities

A series of school-based research and training activities can promote the competencies of teaching and research team, broaden the scope and space for teachers' mutual communication, create a platform to enrich teachers' knowledge and ideas, make reflection on teaching practice, and eventually to improve teachers' professional development.

Acknowledgements

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References


An Exploration of the Significance, Challenges, and Solutions of the E-learning Platform for Middle School Teachers’ Professional Development

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Abstract: The purpose of the present study is to investigate the significance, challenges and solutions of implementing the E-learning platform into middle school teachers’ professional development. Results showed that the convenience, the immediacy of communication, students’ records and information storage, and the development of teachers’ ICT-related competencies were the main features that teachers mostly took advantages of. Meanwhile, teachers reported most frequently of the disadvantages of the operational obstacles, which provided various defects about incorporating communication software during teaching and learning.

Keywords: E-learning platform, teachers’ professional development, middle school

1. Introduction

E-learning platform is a practical platform for interactive teaching and learning. Research has shown that E-learning platform can help improve the academic performance of learners, providing new ideas and methods for pedagogical innovations and teaching reforms (Piper et al., 2018). In recent decades, E-learning platform has attracted increasing interests, and has been widely employed in more and more schools in China. Especially, E-learning platform has playing a significant role in teacher professional development. Indeed, the personalization of the learning process is expected to increase teachers’ satisfaction and learning efficiency (Crecci & Fiorentini, 2018). Nevertheless, the difficulty is how to give full play to the interactive function of the platform and how to improve the enthusiasm of the teachers to use the platform (Heyd-Metzuyanim, Munter, & Greeno, 2018). It should be noted that the insights into the particular influence the E-learning platform exerts in the process of teacher professional development and how it is exercised still need to be developed (Cheng & Wu, 2016). In the present study, an E-learning platform was designed and implemented as a way to promote teacher professional development at a key middle school located in southwest China. This study aims to investigate the significance, challenges and solutions that the E-learning platform has brought about professional development for middle school teachers.

2. Background of the E-learning Platform

First, teachers’ ICT-related competencies were relatively undeveloped. The most commonly used instructional software is WORD, EXCEL, PPT and Flash. However, most teachers only used the basic functions, such as documents processing and spreadsheets creation, etc. Science teachers seldom used the Geometry Sketchpad. Second, the teachers were able to use the computers, IPADs and projectors skillfully, however, the use of these ICT equipment were more to show the PPT slides or arrange classroom exercise, which only played the role of blackboard. Third, the teaching and learning outcomes could not be digitalized. Most teachers could master the existing paperless marking system, which actually was a simple
data-processing system, only deal with the average scores, highest scores and simple item analysis. It was obvious that this system could not meet the requirements for teaching and researching, especially for teachers and students’ individualized development.

In 2018, considering the previous exiting challenges, the Guilin Middle School, collaborated with IFLYTEK Company, implemented an “Internet +” E-learning platform, which incorporated Cloud computing, 5G technology, Big data, Artificial Intelligence (AI) applications, to establish the digital learning ecosystem, promote personalized learning outcomes, support teachers’ professional development and school-based management. The major functions of the E-learning platform system were consisted with Smart Management, Smart Instruction, Smart Learning and Smart School Service. To be specific, the most commonly used sub-system for teachers’ professional development were the big data precise teaching system, the school-based exercises library, the smart classroom system, the new college entrance examination courses arrangement system, and the teachers’ instructional evaluation system. From 2018 to 2019, the big data precise teaching system had been used 501 times to organize the subject examinations, covering 148 teachers and 42 classes in the school. The total number of subject exercises in the school-based exercises library is 1400, and the usage rate was reported at 99.18%. The smart classroom system had been integrated into 4 classes, including 23 teachers and 159 students’ teaching and learning. The new college entrance examination courses arrangement system had simulated 17 courses for the new college entrance examination, accumulated the experience of courses arrangement and further improved the efficiency of curriculum management. The teachers’ instructional evaluation system had been incorporated into the school-based teachers’ professional learning programs, to develop teachers’ ICT-related teaching and learning competencies.

Figure 1. The implementation framework of the E-learning platform in Guilin School
3. Procedure

The participants of this study involved 79 middle school teachers (including 49 female teachers and 30 male teachers) from a key middle school, which was leading the use of E-learning platform in the City of Guilin, southwest China. They majored in different specializations, for example, Chinese, English, Mathematics, Physics, Chemistry, History and Politics. Of them, 62% of them (n=49) were science teachers, while 38% of them (n=30) were liberal arts teachers, aged from 29 to 51. These teachers had at least 4 years of teaching experiences in this school. In 2018, the school redesigned its teacher professional development strategies and integrated the E-learning platform to teachers’ training to equip teachers with ICT-related competencies. Its ultimate goal was to prepare teachers as qualified knowledge instructors equipped with efficient ICT-related competencies, to create or manage teaching resources to transform learning in a meaningful way.

To probe teachers’ view of implementing this E-learning platform, the qualitative case study approach was adopted. Ten focus groups of semi-structured interviews were employed as the main method for data collection. The interview questions were mainly about the challenges, assistance, advantage, and disadvantage of incorporating the E-learning platform into teachers’ learning and teaching. All focus group interviews were audio-taped and transcribed. A constant comparative method was employed for data analysis (Strauss & Corbin, 1990). First, open coding was performed on the transcript of teachers. Categories were followed by grouping the labels on open coding. After that, the relationships between the codes and the categories were explicated through the axial coding. In the constant comparative analysis processes of comprehension and synthesis, the concepts and categories relevant to E-learning platform and teacher professional development were identified and investigated until saturation was reached and carefully woven into descriptions of the teachers’ experiences or practices. Finally, the coding frameworks were derived based on teachers’ responses in order to generate a clearer picture of teachers’ perspectives towards the application of E-learning platform in their own teaching and learning.

4. Finding and Discussion

4.1 The Significance of the E-learning Platform in Teachers Professional Development

First, the E-learning platform optimized the educational resources allocation. With the help of the E-learning platform, the teachers felt convenient to develop school-based learning resources, based on the knowledge framework of textbooks, and systematically constructed teaching resources with teaching design, learning plans and micro-lessons as the main contents. The teachers also established a series of independent learning resource packages with all knowledge points of the whole specialization, in accordance with the teaching resource system of “one lesson and one network”.

Second, the E-learning platform strengthened the immediacy of communications between teachers and students, and among teachers, and further expanded teachers’ classroom teaching space. The E-learning platform provided supports for teachers to use Text, Video, Audio, PPT, Documents, Flash animation and other multimedia technologies to produce learning cases, lesson courseware, and micro lesson preparation. These teaching materials could be uploaded to the E-learning platform for sharing.

Third, the E-learning platform is efficient for students’ and teachers’ records and information storage. Every teacher and student had an individual E-portfolio to keep personal and professional development records. On one hand, the E-learning platform will generate the data of the students’ examination results for the teachers and teachers would grasp the learning situation accurately. On the other hand, the data of teachers’ professional development could be able to store in their E-portfolios, in order to track development records of the teachers. And personal learning data analysis for teachers and students would be generated annual year.

Fourth, the E-learning platform is an effective tool for the development of teachers’ ICT-related competencies. The teachers could participant in the professional courses or programs to develop their ICT-
related competencies through the E-learning platform. Meanwhile, this platform also provided some tests and instructions to guide the teachers as well.

4.2 The Existing Challenges and Solutions for the E-learning Platform Implementation

First of all, the most frequently of the disadvantages of the E-learning platform was the operational obstacles, which provided various defects about incorporating communication software during teaching and learning. The teachers had not been competent enough to deal with the technological problems in the process of teaching and learning. Furthermore, the teachers believed that there should be more network security strategies. Finally, the teachers complained about the application of software and teaching resources were still limited. The practical instructional directions were highly demanded.

The proposed suggestions for establishment of an effective guarantee mechanism to the E-learning platform implemented in teachers’ professional development maybe analyzed from the following perspectives:

- The In-depth Integration for Teachers’ Professional Development

  The school established the Office of Information Application Development and issued the Implementation Plan of Digital Campus in 2018. However, the Office of Information Application Development should work collaboratively with the Office of Teachers’ Development to ensure the E-learning platform integrated with the teachers’ professional learning. Therefore, there is still a need to enhance the space construction and application management for the E-learning platform. For instance, the school should improve the assessment and evaluation standards for teachers’ ICT-related competencies, organize teachers’ professional learning for ICT innovative applications, and fully realize the normalization of ICT instructional applications in the school.

- The Financial Supports

  The school should develop long-term strategies to increase the capital investment for the E-learning platform development. To be specific, it is urgent to give priority to the construction of instructional hardware, and optimize the digital learning environment and resources. In accordance with the MOE of China, the school needs to apply special funds from multi-channels to support the sustained development of the E-learning platform.

- The Information Security

  The school should establish a network security mechanism, to implement the responsibility of school network security, to organize regular educational training sessions on network security, and to regularly arrange technicians to protect the E-learning platform for teachers and students.

5. Conclusion

The purpose of the present study was to identify the significance, challenges and solutions of implementing the E-learning platform into middle school teachers’ professional development. According to the result, the convenience, the immediacy of communication, students’ records and information storage, and the development of teachers’ ICT-related competencies were the main advantages for teachers. Meanwhile, the most frequently of the disadvantages were the operational obstacles. And the proposed solutions were mainly from perspectives of the in-depth integration for teacher professional development, the financial supports, and the information security. In conclusion, the results obtained from the current study may provide feedback and future directions to educators and researchers to improve the E-learning platform implemented in teachers’ professional development.
Acknowledgements

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References


High School Students’ Online Interaction in a Less-developed Region in China

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Abstract: This study reported high school students’ online interaction of learning English during the Covid-19 pandemic in a less-developed region in China. Both quantitative and qualitative data were collected through a semi-structured survey with a questionnaire and several open-ended questions. Data were analyzed based on the Exploratory Factor Analysis and content analysis. Our research findings show that high school students’ online interaction in English language learning included three factors, namely Student-Teacher Interaction, Student-Student Interaction, and Student-Content Interaction. Students expected to have more interaction with teachers in online classes and use advanced technology in the future. They also believed that they could improve their learning efficiency with more online motivating and self-regulation. This study enabled researchers to better understand high school students’ online interaction when learning English online in a less-developed region in China.

Keywords: Online interaction, English language learning, High school students, Online education

1. Introduction

During the Covid-19 pandemic, students were forced to complete a series of learning activities online, which brought various challenges to both teachers and students, particularly for those in less-developed regions. In order to achieve better teaching and learning outcomes, online learning usually requires a high level of interaction among teachers, peers, and the learning contexts. Previous research has investigated the interactive teaching methods, and most of them mainly explored the interaction between teachers and students (Gao, 2020; Xia & Cui, 2013; Zhang, 2019). However, only a few studies focused on English language learners’ online interaction based on the interaction among teachers, students, and the online learning environment. There were scarce research targeting at high school students in minority-populated areas. This research used both quantitative and qualitative data to explore high school students’ interaction in an online English language course during the Covid-19 pandemic in a less-developed region in China, and attempted to report students’ expectations for online interaction in English courses.

2. Literature Review

The quality of interaction is an important indicator for the effectiveness of online education (Sher, 2009). Moore (1993) divided the interaction in online learning into three dimensions, namely, learner-instructor interaction, learner-learner interaction, and learner-content interaction. Learner-instructor interaction refers to teachers’ guidance, encouragement, or evaluation against students and the questions or feedback of the teaching content brought up by students. Learner-learner interaction is defined as group assignments and in-class discussions. Learner-content interaction is the process by which students obtain information from different online platforms or materials. Sabry and Baldwin (2003) studied the relationship between these three types of online interaction and learning styles. Sher (2009) explored the relationship between two types of online interaction (student-instructor and student-student) and learning satisfaction. Cho and his colleagues investigated the relationship between these three kinds of online interaction and self-regulated
learning (Cho & Cho, 2017; Cho & Kim, 2013). At present, the effectiveness of those three types of online interaction have been used to indicate the positive impact of online language teaching on learning (e.g., Li, 2020; Yang & Wang, 2019; Zhang, 2019), but little is known about high school students’ online interaction in English language learning. This study used a questionnaire to conduct qualitative and quantitative analysis on 287 high school English language learners in Qiannan Buyi and Miao Autonomous Prefecture of Guizhou province in China, aiming to explore the following two aspects:

1) What are the factorial structures of high school students’ online interaction of their English language learning during the Covid-19 pandemic?

2) What is high school students’ expectation for ideal online English language learning?

3. Methodology

3.1 Research Context

This research aimed at analyzing online interaction in English language learning of high school students in a less-developed region in China during the Covid-19 pandemic. It was conducted at Changshun Senior High School of Nationalities, which is an ethnic Senior High School in Changshun County, Qiannan Buyi and Miao Autonomous Prefecture of Guizhou Province in China. The majority of the students in this school are mainly from Buyi, Miao, and Han ethnicity.

Due to the lack of computers or multimedia platforms in the school, students seldom carried out online language learning and were relatively unfamiliar with online learning methods and learning environments. However, during the epidemic, online English courses were adopted, which provided high school students with a new access for studying English online.

3.2 Participants

A total of 287 senior one (first year in high school) students at Changshun Senior High School of Nationalities were invited to join the research. There were 145 males and 142 females. Their ages ranged from 17 to 20. 114 of our participants (39.72%) are from Buyi ethnicity, 97 of them (33.80%) from Han ethnicity, and 74 of them (25.78%) from Miao ethnicity. There were both one student (0.35%) from Shui ethnicity and Tujia ethnicity. Among those participants, 152 students (52.96%) used E-net to study English online, and 57 students (19.86%) and 28 students (9.76%) used Dingding and Tencent Conference to participate in real-time interactive online English courses. 245 students (85.37%) watched recorded online courses through SkyQian. 23 students (8.01%) used Wechat and QQ and 25 students (8.71%) used other online platforms for learning English online.

3.3 Instrument

This research conducted an investigation on high school students’ online interaction in a less-developed region during the Covid-19 pandemic in China. A questionnaire of online interaction in English language learning was used in the research. The questionnaire was adapted from the previous questionnaire for students’ interaction in Web-based online learning environment (Sher, 2009) and was compiled using Likert five-level scale, ranging from 1 as “strongly disagree” to 5 as “strongly agree”. Considering the English proficiency level of our participants, all items in the questionnaire were translated into Chinese. At the same time, eight open-ended questions were designed according to students’ online interaction in English language learning, aiming to collect and analyze the data qualitatively. Based on the theoretical framework of online interaction (Moore, 1993), the researchers defined three dimensions to analyze the data, namely Student-Teacher interaction, Student-Student interaction, and Student-Content interaction.
3.4 Data Analysis

Both quantitative and qualitative data were collected in the research. The quantitative data were processed with SPSS 20.0 and the qualitative data were transcribed and then summarized by researchers. Combining the two research questions, the procedure of data analysis was conducted as followed:

(1) The Exploratory Factor Analysis (EFA) and reliability analysis were used to determine the reliability and validity of the questionnaire. Then the study explored the factorial structure of high school students’ online interaction in English language learning.

(2) Researchers adopted a content analysis method to analyze students’ responses to open-ended questions. They summarized the current situation of online interaction among the high school English language learners in a less-developed region.

4. Results

4.1 Quantitative Results

The research investigated the factorial structures of high school students’ online interaction of their English language learning during the Covid-19 pandemic in China. The findings through EFA indicated that high school students’ online interaction in English language learning includes three different factors. The instrument displayed similar factor structures as revealed by previous work (e.g., Sher, 2009; Yang & Wang, 2019), and had satisfactory reliability.

Table 1 shows the results of EFA for the questionnaire of online interaction. Researchers used the principle component analysis as the extraction method, and the Varimax with Kaiser Normalization as the rotation method (Kaiser, 1958). Three factors were included in this result, namely “Student-Teacher Interaction (ST)”, (α = 0.75, Mean = 3.61, S.D. = 0.65), “Student-Student Interaction (SS)”, (α = 0.67, Mean = 3.42, S.D. = 0.69), and “Student-Content Interaction (SC)”, (α = 0.65, Mean = 3.50, S.D. = 0.65). The total variance explained was 71.47%. The overall alpha of this research was 0.77, and the alpha coefficient of this study was around 0.65-0.70 for each factor. The results clearly indicated that the internal consistency of all factors was sufficient for statistical analysis.

<table>
<thead>
<tr>
<th>Factor 1: ST</th>
<th>Factor 2: SS</th>
<th>Factor 3: SC</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST34: 0.73</td>
<td>SS37: 0.83</td>
<td>SC42: 0.79</td>
</tr>
<tr>
<td>ST35: 0.75</td>
<td>SS38: 0.84</td>
<td>SC43: 0.77</td>
</tr>
<tr>
<td>ST36: 0.80</td>
<td>SS39: 0.74</td>
<td>SC44: 0.81</td>
</tr>
<tr>
<td>Factor 2: SS, α = 0.67, Mean = 3.42, S.D. = 0.69</td>
<td>Factor 3: SC, α = 0.65, Mean = 3.50, S.D. = 0.65</td>
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</tr>
</tbody>
</table>

Note. Overall alpha: 0.77; total variance explained: 71.47%.

4.2 Qualitative Results

This research designed several open-ended questions to explore high school students’ expectation for interaction in online English classes. Researchers found that English learners in high school showed various expectations for online English classes from different perspectives (Table 2). First of all, most
students emphasized online in-class interaction with teachers. They expected online English courses to be more interesting and more interactive. For example:

“You can communicate with the teacher in real-time. You don’t need to ask permission one by one to raise questions like learning by Dingding.” (selected and translated from students’ response to open-ended questions)

“We can tell English stories, watch English movies together, and using online microphones to share our thoughts.” (selected and translated from students’ response to open-ended questions)

“Problems can be solved in time. It is convenient to exchange ideas and search for information online. The class atmosphere is active.” (selected and translated from students’ response to open-ended questions)

Secondly, some high school students expected to be monitored by teachers, peers, or parents when taking courses online. They also hoped that the online platform they use can be improved to help monitor their learning conditions. Some students believed that online classes could provide them with an opportunity to regulate their study.

“Compared with classroom classrooms, it (taking online courses) is more contemporary and requires more technological literacy.” (selected and translated from students’ response to open-ended questions)

“With the advancement of technology in the future, the image of the teacher can be shown directly in front of us through virtual projection.” (selected and translated from students’ response to open-ended questions)

“The teacher can enlarge her PPT as soon as possible when explaining some important and difficult points so that we can take notes.” (selected and translated from students’ response to open-ended questions)

Table 2. High school students’ expectation for ideal online English language learning.

<table>
<thead>
<tr>
<th>Perspectives</th>
<th>Factors</th>
<th>Students’ expectation</th>
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</thead>
<tbody>
<tr>
<td>Student-Teacher Interaction (ST)</td>
<td>Students’ expectation for teachers</td>
<td>Correcting homework online</td>
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<tr>
<td></td>
<td></td>
<td>Giving timely feedback online</td>
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<td></td>
<td></td>
<td>Providing encouragement and giving praise</td>
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<td></td>
<td>Providing targeted instruction to specific students</td>
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<td></td>
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<td>Teaching at a moderate speed</td>
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<td></td>
<td></td>
<td>Having clear page layout and handwriting</td>
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<tr>
<td></td>
<td></td>
<td>Monitoring whether students are paying attention to online classes</td>
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<td></td>
<td></td>
<td>Giving thorough explanations of courses</td>
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<td>Being able to stimulate learning interest</td>
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<td></td>
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<td>Using only English to teach</td>
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<tr>
<td></td>
<td></td>
<td>Introducing more online activities in class</td>
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<tr>
<td></td>
<td></td>
<td>Teaching students in accordance with their aptitude</td>
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<tr>
<td></td>
<td>Students’ expectation for themselves</td>
<td>Doing homework more carefully</td>
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<td>Handing in homework on time</td>
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<td></td>
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<td>Having enough time to think independently</td>
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<td>Asking questions instantly in online classes</td>
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<td></td>
<td></td>
<td>Paying full attention to online classes</td>
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<tr>
<td></td>
<td></td>
<td>Discussing problems and no plagiarism</td>
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<tr>
<td></td>
<td></td>
<td>Having multi-person interaction in online classes</td>
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<tr>
<td></td>
<td></td>
<td>Seeking help from others</td>
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<tr>
<td></td>
<td></td>
<td>Conducting real-time discussion in online classes</td>
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<tr>
<td></td>
<td></td>
<td>Developing self-regulated collaborative learning</td>
</tr>
<tr>
<td></td>
<td>Students’ expectation for peers</td>
<td>Having an appropriate amount of homework</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Attaching importance to fundamental linguistic</td>
</tr>
</tbody>
</table>

545
Having a simple and clear structure of teaching materials
Having an appropriate size of characters on the screen
Improving the clarity of online materials
Using practical teaching equipment (live-broadcasting platforms)
Synchronizing teacher lecturing with online presentations without deferring
Achieving face-to-face teaching virtually
Developing a complete supervision system

5. Conclusion

The results indicated that high school students’ online interaction in English language learning included three factors, namely Student-Teacher Interaction, Student-Student Interaction, and Student-Content Interaction. Students expected to promote effective online interaction with their teachers. They also hoped that new technologies can be used in the future to achieve more vivid and realistic online teaching. Besides, high school students also believed that online English language learning can enhance their ability of self-regulatory and independent learning.

This study provided researchers with more insights for further understanding high school students’ online interaction when learning English online. More empirical studies are required to obtain data from students of different grades and at English language proficiency levels. The factor structure of online interaction can be applied to analyze data from a larger number of high school students. Further research will provide new perspectives for experts to design and implement online English language teaching in less-developed areas.

Acknowledgments

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References


Virtual Reality in Language Learning: A Literature Review of Empirical Studies in Recent Ten Years

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Abstract: In the past decade, the application of virtual reality (VR) in language learning has attracted increasing attentions in the field of computer-assisted language learning (CALL). This research systematically reviewed 55 empirical studies focusing on the application of VR in language learning published by 11 high impact journals in and beyond China over the past decade (2010-2019). A coding scheme and analytic framework was defined to systematically analyze the general publication trends, including publication numbers, target languages, and research methods. Moreover, we summarized seven main research themes and analyzed the affordances and challenges of the VR applications in language learning. This systematic literature review fulfilled the need to map the current research status, and it also provided some insights for future research and development of VR in the field of CALL.

Keywords: Virtual reality, language learning, systematic literature review

1. Introduction

The application of emerging technologies for educational purposes has brought profound changes in the way students learn languages. Among them, the virtual reality (VR) technology has shown great potential in language education. It overcame the limitations of physical classrooms and provided immersive and simulated contexts for language learners, giving them an authentic environment to communicate in foreign language and experience diverse cultures in the virtual world (Shih, 2015). Besides, it integrated multiple interaction channels, such as video-based synchronous online communication, with simulated avatars and virtual reality systems (Shih, 2014). Due to the unique features of immersive contexts, multimode communication channels, and synchronous interactions (Lan et al., 2016), VR had attracted considerable attention in the field of computer-assisted language learning (CALL). In the past decade, several studies were conducted to explore the effect of the application of VR in language learning (e.g., Melchor-Coutor, 2018; Xie, Chan, & Ryder, 2019), but there are still few systematic literature reviews on the use of VR for language learning. Using the similar research method with previous study (Zheng et al., 2019), the current research kept track on the development of the application of VR in language learning and selected the latest studies from 2010-2019. Out of the need to map the current research status, 55 empirical studies focusing on the application of VR in language learning published by 11 high impact journals in and beyond China over the past decade were finally reviewed.

1. Research Design

1.1 Research Questions

Employing the systematic content analysis, the current research reviewed 55 empirical studies focusing on the application of VR in language learning published by 11 high impact journals in and beyond China from
2010 to 2019. It aimed to analyze the current status and future development of the application of VR in language learning by addressing the following research questions:

- What are the general publication trends of the reviewed empirical studies about the application of VR in language learning from 2010 to 2019?
- What are the research foci of the reviewed empirical studies about the application of VR in language learning from 2010 to 2019?
- What are the affordances and challenges of VR for language learning according to these empirical studies?

1.2 Data Collection and Analysis

Since the application of VR in language learning is still an emerging research topic with focused research groups, we mainly selected research articles published by the leading journals in the field of CALL. Based on previous studies (e.g., Hsu, Hung, & Ching, 2013; Shih, Feng, & Tsai, 2008), six high impact journals in the field of CALL beyond China were selected for this research. Five of them are Social Science Citation Index (SSCI) source journals, including: Computer Assisted Language Learning (CALL), ReCALL, Computers & Education (C&E), Language Learning & Technology (LLT), and System. Besides, CALICO Journal is also included as a very important and representative journal in the field of CALL. Then, “VR” and “language learning” were used as keywords to search relative publications in the China National Knowledge Infrastructure (CNKI) from 2010 to 2019. According to the research results, five Chinese Social Science Citation Index (CSSCI) source journals with relatively larger number of studies and high impact were selected, including: Modern Educational Technology (MET), China Educational Technology (CET), Technology Enhanced Foreign Language Education (TEFLE), Open Education Research (OER), and Distance Education in China (DEC). Researchers browsed the titles, abstracts, and keywords of all articles published in the 11 journals over the past decade (2010-2019), and finally selected 55 empirical studies focusing on the application of VR in language learning.

Following the coding system in previous research (Chai, Koh, & Tsai, 2013; Zheng et al., 2019), a coding scheme and analytic framework was defined to systematically analyze the general publication trends, including publication numbers, target languages, and research methods. Moreover, we summarized seven main research themes and analyzed the affordances and challenges of the VR applications in language learning.

2. Results and Discussion

2.1 General Publication Trends

Publication Numbers

As shown in Figure 1, the number of empirical studies published in 11 journals per year is between three to nine, which is still quite small, indicating that the relevant research is still in the initial stage. If looking at the change over the past ten years, the overall trend is to increase in the twists and turns, and 2019 witnessed the largest number of empirical research publications. We also counted the numbers of empirical studies published by each journal from 2010 to 2019, as indicated in Figure 2. Three journals, including CALL, ReCALL, and C&E, published relatively more empirical studies (not less than ten) concerning the applications of VR to language learning. Besides, it’s obvious that the number of empirical studies published in domestic journals is far less than that of international journals. Therefore, we expect that more related empirical studies could be conducted in China in the next few years.
In terms of the target languages, English is certainly the dominant language of the reviewed 55 studies. More than sixty percent of the reviewed articles (35 studies) targeted at the English language teaching and learning, in which, 31 studies focused on English only, while the other four studies focused on English and other languages at the same time. No one would deny that English has already become the lingua franca of the world (e.g., Lan, 2015). In addition, as illustrated by Figure 3, a few articles concerned the applications of VR in Chinese and Spanish language learning, with eight studies and seven studies respectively. Apart from that, very little research put attention on the less commonly taught languages learning with VR applications. However, we need to realize that in this globalization era, it is also crucial to preserve the cultural and linguistic diversity. VR could create authentic environment for language learners who lack context for language communication, and therefore be used for reviving languages in crisis (Dalton & Devitt, 2016).
Among the empirical studies we reviewed, 29 studies (more than half of the total) employed the mixed research method, 18 studies and 8 studies employed quantitative method and qualitative method respectively, as indicated in Figure 3. It’s not hard to understand the popularity of the mix methods in these studies. VR based virtual environment provided authentic contexts for language learners, and complicated interactions and multimodal communications happened in the language learning process (e.g., Mroz, 2015). In this situation, mixed method is a good choice to amend the inherent flaws of pure qualitative or quantitative method (Creswell et al., 2003). Both qualitative and quantitative data could be collected and analyzed, which enables researchers to have a more comprehensive understand of the issues.

2.2 Research Foci

Based on content analysis, this research summarized seven main research themes, including language learner characteristics, affordances of VR for improving learners’ linguistic knowledge and non-linguistic
skills, design features of language-learning tasks, the nature of interactions, design and development of VR platforms, and teachers’ role and teacher development, as indicated in Table 1. Among the reviewed studies, several studies concerned more than one research theme. For instance, Mei and Zhu (2019) designed immersive embodied teaching environment and took the project-based teaching of business English, finding that the environment could improve students’ learning efficiency and interpreting ability. In general, the most popular topic was language learner characteristics, such as learning engagement, learning efficiency, learning anxiety, etc. Besides, the affordances of VR for improving learners’ linguistic knowledge and non-linguistic skills also attracted much attention. However, only three studies focusing on language teachers’ role and development. There is no doubt that teachers play an important guiding role in the process of language learning, especially in the complicated virtual environments (Wang, 2015). Therefore, more empirical studies concerning language teachers’ role should be conducted in the future.

Table 1. Main Research Themes

<table>
<thead>
<tr>
<th>Main research themes</th>
<th>Number of empirical studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Language learner characteristics</td>
<td>32</td>
</tr>
<tr>
<td>Affordances for improving learners’ linguistic knowledge</td>
<td>31</td>
</tr>
<tr>
<td>Affordances for improving learners’ non-linguistic skills</td>
<td>25</td>
</tr>
<tr>
<td>Design features of language-learning tasks</td>
<td>15</td>
</tr>
<tr>
<td>The nature of interactions</td>
<td>11</td>
</tr>
<tr>
<td>Design and development of VR platforms</td>
<td>8</td>
</tr>
<tr>
<td>Language teachers’ role and teacher development</td>
<td>3</td>
</tr>
</tbody>
</table>

2.3 Affordances and Challenges of the VR Applications in Language Learning

The immersive and simulated contexts supported by VR made it possible for language learners to overcome the limitations of physical classrooms and freely wander in the virtual world to experience diverse cultures, and being fully engaged in the language learning activities (Peterson, 2012; Shih, 2015). Besides, some multi-user virtual environments (MUVEs) characterized by the avatar showed great potential to decrease learners’ anxiety and improve their self-confidence for its anonymity (Melchor-Couto, 2018). In addition, these MUVEs offered multimodal interaction channels for language learners from different cultural backgrounds to interact with each other through texts, voice, and videos synchronously or asynchronously (Wigham & Chanier, 2015). However, there are still some challenges for the effective use of the VR application in language learning. On one hand, the limitation of the internet bandwidth (Levak & Son, 2017) and the cost of related high-quality computer devices (Chen, 2016) pose challenges in the accessibility. On the other hand, the cognitive load caused by the complicated operation of the virtual environment systems and the complexity of learning tasks design (Lan, 2014) present new challenges for its future applications.

3. Conclusion

Employing the content analysis method, this study systematically reviewed 55 empirical studies focusing on the application of VR in language learning published by 11 high impact journals in and beyond China from 2010 to 2019. A coding scheme and analytic framework was postulated to analyze the general publication trends, including publication numbers, target languages, and research methods. Besides, we summarized seven main research themes and analyzed the affordances and challenges of the VR applications in language learning. The results showed that the relevant research is still in the initial stage with relatively less studies. However, although the VR technologies were not mature enough and encountered several challenges, it showed great potential in promoting students’ linguistic knowledge and non-linguistic skills, decreasing learners’ anxiety, and improving learning efficacy. In addition, more empirical studies could be conducted to explore the potential effectiveness of applying VR technologies in special education and reviving languages in crisis.
Acknowledgements

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References

Exploring High School Students’ Conceptions of Learning English Online in a Less-developed Region in China

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Abstract: The outbreak of Covid-19 pandemic in China has suddenly changed the high school English language teaching and learning in less-developed regions, transforming offline classroom learning into online home-based learning. The changes of learning environments and learning methods brought new challenges to students’ English language learning. It’s believed that learners’ conceptions of learning had influences on their learning process and learning outcomes. In this case, the current research aimed to explore high school students’ conceptions of learning English online in the less-developed region through a large-scale questionnaire investigation. The participants were 209 twelfth grade students from Changshun Senior High School of Nationalities in Guizhou province, China. Both quantitative and qualitative data were collected based on the conceptions of learning English online (COLE) questionnaire. First, exploratory factor analysis and Cronbach’s alpha test were conducted to examine the validity and reliability of the questionnaire, and further confirmed the factorial structures of high school students’ conceptions of learning English online in the less-developed region. Then, students’ subjective responses to the open-ended question were coded and analyzed. Four major factors affecting students’ conceptions of learning English were identified, namely learning experience, discipline-based learning content, classroom teaching, and school culture. The qualitative results provided positive implications for guiding high school students to establish appropriate conceptions of learning English. It’s advised that English instructors should choose suitable teaching materials with appropriate difficulty and interesting content to stimulate students’ interest in learning English. Besides, it’s very important that English teachers should pay attention to their professional skills training and development and establish appropriate conceptions of learning English first. Finally, a good learning environment with pleasant and atmosphere and rich opportunities to communicate is needed to help guide students’ to develop sophisticated conceptions of learning English.

Keywords: Conceptions of learning English, online English language learning, less-developed region

1. Introduction

The rapid development of information and communications technology has brought great changes to the approaches of English teaching and learning. In the field of second language acquisition (SLA), lots of researchers have paid increasing attention to the potential and effectiveness of learning English language in an online or blended environment (e.g., Thang & Bidmeshki, 2010; Thang et al., 2012). However, the English teaching reform from offline to online and related studies were conducted mostly in higher education or secondary education in first-tier cities. For high school English language teaching and learning in less-developed regions, it’s still mainly based on face to face classroom teaching, and students nearly had no online learning experience. Unexpectedly, the outbreak of Covid-19 pandemic in China has suddenly changed the condition. Affected by the Covid-19 pandemic, Qiannan Bouyei and Miao Autonomous Prefecture of Guizhou Province adopted online education practice for the first time, transforming offline classroom learning into online home-based learning. In this case, students’ learning
environments and learning methods have changed greatly, which brought new challenges to their English language learning.

Conceptions of learning refer to what individuals think learning objectives and process are (Benson & Lor, 1999). In the past few decades, many educators and researchers have been focusing on exploring learners’ beliefs or conceptions of learning (Ali et al., 2018; Säljö, 1979; Tsai, 2004; Vezzani et al., 2018), and showed some evidences that learners’ conceptions of learning had influences on learning process and learning outcomes (Lee et al., 2008; Peterson et al., 2010; Pinto et al., 2018). Therefore, it’s important for researchers to understand learners’ conceptions of learning. This research aimed to explore high school students’ conceptions of learning English online in the less-developed region through a large-scale questionnaire investigation. By revealing the factorial structures of high school students’ conceptions of learning English and major factors affecting learners’ conceptions of learning English, the study provided positive implications for guiding high school students to establish appropriate conceptions of learning English online.

2. Literature Review

Conceptions of learning can be regarded as what individuals think learning objectives and learning process are (Benson & Lor, 1999). The earliest research about conceptions of learning can date from Säljö’s (1979) study. Säljö interviewed ninety Swedish people with a wide range of educational backgrounds and age about what they actually meant by learning, and distinguished five qualitatively different conceptions of learning: (1) learning as an increase in knowledge, (2) memorizing, (3) an acquisition of facts or principles, (4) an abstraction of meaning, and (5) an interpretive process aimed at understanding reality. Following Säljö, many educators and researchers have been focusing on exploring learners’ conceptions of learning in general in the past few decades (Entwistle & Peterson, 2004; Negovan et al., 2015; Vezzani et al., 2018). Liu (2005) identified conceptions of learning as “an epistemological belief system of individual students for knowledge and learning”, and further claimed that its formation and development were influenced by factors such as learning experience, discipline-based learning content, classroom teaching, and school culture.

Some researchers contended that the conceptions of learning are domain dependent (Buehl & Alexander, 2001; Hofer, 2000; Tsai, 2004), which means that the same individual may have different conceptions when learn different subjects, such as chemistry and politics (Tsai, 2004). Therefore, various studies investigated learners’ conceptions of learning in specific domains, such as science (Tsai, 2004), management (Lin & Tsai, 2008), biology (Chiou et al., 2012; Sadi, & Lee, 2018), and English (Luan & Zheng, 2017; Zheng et al., 2016). Although a variety of studies have been conducted to explore learners’ conceptions of learning (Chiu et al., 2016; Lin & Tsai, 2008; Tsai, 2009; Vezzani et al., 2018), limited research has focused on high school students’ conceptions of learning English online in a less-developed region.

The current study aimed to explore high school students’ conceptions of learning English online in the less-developed region by answering the following two questions:

- What are the factorial structures of high school students’ conceptions of learning English?
- What are the major factors affecting high school students’ conceptions of learning English?

3. Research Method

3.1 Research Context

The study was conducted in Changshun Senior High School of Nationalities, the only public senior high school in Changshun County, Qiannan Bouyei and Miao Autonomous Prefecture, Guizhou Province. Changshun county was a national-level poverty-stricken county, and now it’s a key county in the new stage
of national poverty alleviation development. According to the classification, this school belonged to the third level general high school, which meant that both the teaching resources and the quality of the students are relatively not very good. The school has a population of 4176 students, and over 70% are ethnic minorities. This ethnic senior high school was a boarding school and implemented closed-end management. The school was equipped with only four multimedia classrooms, and students were not allowed to use electronic devices such as mobile phones during school. Restricted by the objective condition, students had fewer opportunities to carry out online learning, and therefore lacked relevant experience in online English language learning.

3.2 Participants

Through random sampling method, 209 twelfth grade students were randomly selected to participate in the survey, including 143 females (68.4%) and 66 males (31.6%). The participants consisted of 90 Bouyei students (43.1%), 60 Miao students (28.7), 57 Han students (27.3%), and 2 Yi students (0.9%). Their ages ranged from 17 to 23 years, with an average of 19.29 years (SD=0.91). According to the questionnaire data, 164 students (78.5%) didn’t have any online course learning experience before the outbreak of the Covid-19 pandemic, so most of them were unfamiliar with online learning environments and online learning methods. Besides, a total of 180 students (86.1%) were satisfied or very satisfied with their online English course, and only 122 students (58.4%) were satisfied or very satisfied with their online learning performance.

3.3 Instrument

This research employed a questionnaire to explore high school students’ conceptions of learning English online in the less-developed region. The questionnaire consisted of two parts. The first part was the conceptions of learning English online (COLE) questionnaire, which adapted from previous questionnaires (Liang & Tsai, 2010; Zheng et al., 2016) and modified according to local students. All the items in the first part were measured with a five-point Likert scale, from 1 “I do not agree at all” to 5 “strongly agree”. The second part of the questionnaire was an open-ended question aiming to explore major factors affecting students’ conceptions of learning English. Since English is a foreign language for the participants, the whole questionnaire was translated into Chinese.

3.4 Data Collection and Analysis

In the current research, 209 twelfth grade students were randomly selected to respond to the questionnaire voluntarily. After collecting all the effective questionnaires, the study analyzed the data in two steps. First, exploratory factor analysis and Cronbach's alpha test were conducted to examine the validity and reliability of the questionnaire, and further confirmed the factorial structures of high school students’ conceptions of learning English online in the less-developed region. Second, the researchers coded all 209 participants’ subjective responses to the open-ended question, and further summarized them from different perspectives. To protect participants’ privacy, the participants were identified as S001-S209 according to the time the questionnaire was submitted. For instance, the first student to submit the questionnaire was coded as S001, and the last was S209. Since the questionnaire was presented in Chinese, the researcher translated participants’ responses into English.

4. Results and Discussions

4.1 Exploratory Factor Analysis of the COLE Questionnaire
At first, the study conducted exploratory factor analysis and Cronbach's alpha test to examine the validity and reliability of the questionnaire. As shown in table 1, the final version of the COLE questionnaire consisted of eight factors and 36 items in total. The eight factors were “Meeting the requirements (MR)” (α=0.92, Mean=2.72, S.D.=0.89), “Memorizing (Me)” (α=0.75, Mean=3.33, S.D.=0.73), “Testing (Te)” (α=0.83, Mean=2.57, S.D.=0.76), “Drills and practice (DP)” (α=0.76, Mean=3.62, S.D.=0.54), “Increasing one’s knowledge (IK)” (α=0.81, Mean=3.71, S.D.=0.58), “Applying (Ap)” (α=0.89, Mean=3.30, S.D.=0.67), “Understanding (Un)” (α=0.87, Mean=3.54, S.D.=0.58), and “Seeing in a new way (Se)” (α=0.92, Mean=3.83, S.D.=0.60). The total variance explained was 69.94%. The alpha coefficient for each factor of this study ranged from 0.75 to 0.92 (overall alpha=0.79). The above data indicated that the questionnaire has high validity and reliability, and could be used to measure high school students’ conceptions of learning English.

According to the results, most dimensions were consistent with the research findings about the internal structure of students’ conceptions of learning English of previous studies (Luan & Zheng, 2017; Zheng et al., 2016). Compared with the results of Zheng et al. (2016) study, only one dimension was different. This questionnaire removed the dimension “Grammar, vocabulary and pronunciation”, and added the unique dimension “Meeting the requirements”. The study was conducted in a less-developed region, and for participants in this research, English language was quite far from their present lives. Some students didn’t want to learn English at all, but they had to because of the external rules. Students who had the conception of “Meeting the requirements” took a very negative attitude towards English learning, and some of them even gave up learning English. This research results offered English teachers a wake-up call, and provided important implication for English teachers to guide students to establish right conceptions of learning English.

Table 1. Rotated factor loadings and Cronbach's alpha values for the eight factors of the COLE (n=209)

<table>
<thead>
<tr>
<th>Factor 1: Meeting the Requirements (MR), α=0.92, Mean=2.72, S.D.=0.89</th>
<th>Factor 2: Memorizing (Me), α=0.75, Mean=3.33, S.D.=0.73</th>
<th>Factor 3: Testing (Te), α=0.83, Mean=2.57, S.D.=0.76</th>
<th>Factor 4: Drills and Practice (DP), α=0.76, Mean=3.62, S.D.=0.54</th>
<th>Factor 5: Increasing one’s Knowledge (IK), α=0.81, Mean=3.71, S.D.=0.58</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR 1</td>
<td>0.85</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MR 2</td>
<td>0.89</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MR 3</td>
<td>0.86</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MR 4</td>
<td>0.82</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Me 1</td>
<td></td>
<td>0.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Me 2</td>
<td></td>
<td>0.79</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Me 3</td>
<td></td>
<td>0.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Te 1</td>
<td></td>
<td>0.86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Te 2</td>
<td></td>
<td>0.83</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Te 3</td>
<td></td>
<td>0.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Te 4</td>
<td></td>
<td>0.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DP 1</td>
<td></td>
<td></td>
<td>0.75</td>
<td></td>
</tr>
<tr>
<td>DP 2</td>
<td></td>
<td></td>
<td>0.62</td>
<td></td>
</tr>
<tr>
<td>DP 3</td>
<td></td>
<td></td>
<td>0.52</td>
<td></td>
</tr>
<tr>
<td>DP 4</td>
<td></td>
<td></td>
<td>0.57</td>
<td></td>
</tr>
<tr>
<td>DP 5</td>
<td></td>
<td></td>
<td>0.66</td>
<td></td>
</tr>
<tr>
<td>IK 1</td>
<td></td>
<td></td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td>IK 2</td>
<td></td>
<td></td>
<td>0.73</td>
<td></td>
</tr>
</tbody>
</table>
Factor 6: Applying (Ap), $\alpha=0.89$, Mean=3.30, S.D.=0.67

| Ap 1 | 0.69 |
| Ap 2 | 0.81 |
| Ap 3 | 0.80 |
| Ap 4 | 0.76 |
| Ap 5 | 0.68 |

Factor 7: Understanding (Un), $\alpha=0.87$, Mean=3.54, S.D.=0.58

| Un 1 | 0.65 |
| Un 2 | 0.73 |
| Un 3 | 0.67 |
| Un 4 | 0.75 |
| Un 5 | 0.70 |

Factor 8: Seeing in a New Way (Se), $\alpha=0.92$, Mean=3.83, S.D.=0.60

| Se 1 | 0.72 |
| Se 2 | 0.80 |
| Se 3 | 0.79 |
| Se 4 | 0.82 |
| Se 5 | 0.79 |
| Se 6 | 0.74 |

Note: Overall alpha=0.79; total variance explained=69.94%.

4.2 Factors Affecting Learners’ Conceptions of Learning English

Qualitative data were collected from the open-ended question in the second part of the questionnaire. According to Liu’s studies (2005), the formation and development of students’ conceptions of learning was affected by learning experience, discipline-based learning content, classroom teaching, and school culture. In this research, participants’ responses were coded from the four dimensions mentioned above, as indicated in Table 2.

Table 2. Factors Affecting High School Students’ Conceptions of Learning English

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Aspects</th>
<th>Keywords</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning experience</td>
<td>Learning behaviors</td>
<td>Working hard</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Developing own learning approaches</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seeking help</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>English language ability</td>
<td>Getting satisfactory scores</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Having a good command of knowledge</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Using English to communicate</td>
<td>11</td>
</tr>
<tr>
<td>Discipline-based learning content</td>
<td>Degrees of difficulty</td>
<td>Being easy</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Being suitable for high school students</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Features</td>
<td>Being interesting</td>
<td>3</td>
</tr>
<tr>
<td>Classroom Teaching</td>
<td>Teachers’ behaviors</td>
<td>Teaching in English</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interacting with students</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Teaching methods</td>
<td>Focusing on knowledge</td>
<td>4</td>
</tr>
</tbody>
</table>
Having diverse activities 6

Classroom atmosphere Being fascinating and lively 15

Learning environment Communicating in English 12

Learning atmosphere Being pleasant 31

Learning cooperatively 5

Being Free 7

4.2.1 Learning Experience

In the learning experience dimension, many students hoped they could keep working hard and doing lots of exercises. For example,

S157: I need to work terribly hard.
S177: I should learn all the time.
S167: I plan to read English words and compositions in the morning and do exercises in the afternoon.
S130: I need to memorize vocabulary and grammar rules every day.

Apart from this, some students expected to develop their own learning approach, and be able to seek help when meet difficulties.

S021: I hope I can have my own way of thinking and learning.
S117: I hope we can discuss with our classmates, and seek help from our teachers when we have difficulties.

In addition, some students described the English language ability they wanted to achieve. A few of students took scores as the criterion of English language ability. Two students had low expectations with the hope of “pass the exams” (S086, S162), and another two students hoped “get high scores in exams” (S084, S098). More students expressed their expectations of having a command of knowledge and being able to communicate in English. For instance,

S010: I hope I can meet the standard of a high school student in listening, speaking, reading and writing.
S085: I hope I can fully understand the meaning of a passage.
S136: I hope I can communicate with others in simple English.

In summary, it’s obvious that students who stressed memorizing words and doing exercises held the conceptions of learning English as “memorizing” or “drills and practices”. Students who took scores as the measurement tented to have the conception of learning English as “testing”, while those highlighted the command of knowledge were likely to consider learning English as “increasing one’s knowledge”. According to previous research (Liu, 2005), students’ conceptions of learning are formed based on their learning experience. The results provided implications that English instructors could guide students to develop their conceptions of learning English through changing students’ learning experience.

4.2.2 Discipline-based learning content

As for the discipline-based learning content, students expected their ideal English language learning to be interesting and informative. For instance,

S043: I hope it should be easy to understand, and accord with students’ learning logic.
S068: I hope learning English can be easy and interesting.
I hope the high school English knowledge can be as simple as what we learnt in elementary school.

In general, students hoped the content could be interesting and relatively easy to understand. As a foreign language, English is far from students’ life in the less-developed region. The English language learning environment with limited exposure to English and few opportunities to use English may cause them to feel difficult and bored (Wang, 2016). In this case, it’s easy for students to form the conceptions of learning English as “meeting the rules” or “testing”. Therefore, it’s advised that English instructors should choose suitable teaching materials with appropriate difficulty and interesting content to stimulate students’ interest in learning English.

4.2.3 Classroom Teaching

Then, students’ expectations for classroom teaching were analyzed. First, students had the same expectations that teachers could teach in English and have more interactions with them. For instance,

S003: I hope my teacher can teach in English with standard pronunciation.
S101: I hope my teacher can show us some English videos in classes, and can fluently communicate with us in native English.
S166: I wish our teachers can interact with us frequently, instead of teaching mechanically.

In terms of teaching methods, however, the students had different expectations. Some hoped the teacher could focus on English knowledge, while others wanted diverse activities.

S120: I hope my teacher pay more attention to let us recite the vocabulary and do English practices, so that we can better understand and analyze sentence components.
S150: I hope we can have English classes in an entertainment way, learning by gaming.

In addition, students also took classroom atmosphere into consideration. As indicated in their answers, they expected a fascinating and lively English classroom atmosphere.

S093: I hope the classroom is harmonious and students are active.
S180: I want an active and lively class.

To sum up, most students hoped a lively English class with diverse activities and more interactions. At the same time, they excepted English, rather than Chinese, could become their classroom language. The findings of this research were consistent with Liu’s study (2005), who claimed that “teachers’ teaching process, methods and language” would influence students’ conceptions of learning. The results partly reflected the deficiency of local English education, that is, the lack of excellent English teachers and advanced teaching methods in less-developed regions (Wang, 2016; Zhang & Wang, 2018). Therefore, we suggest English teachers should pay more attention to professional skills training and development. Only when English teachers themselves have right conceptions of English language teaching and learning, can they influence and guide students to establish appropriate conceptions of learning English.

4.2.4 School Culture

Further, school culture was an important factor affecting the formation and development of students’ conceptions of learning English. The students wanted a learning environment offering them lots of opportunities to communicate in English.

S001: I hope we have a good English language learning environment, and we all like to communicate in English.
S005: I hope we can communicate with others in English actively, thus making English integrate into our daily lives.

S127: I hope there are some foreign friends around us.

Besides, the students also highlighted the collaborative learning. For example,

S103: I think we should help each other when learning English.
S107: I want to study together with my classmates and teachers.

What’s more, the students yearned for a pleasant and free learning atmosphere, as shown in their responses. Many students used “relaxed and pleasant” (e.g., S008, S077, S165), “free and open” (e.g., S002, S171) as the keywords to describe their ideal learning atmosphere.

In a word, students wished to learn and use English with people around them in a pleasant and free atmosphere. Students’ conceptions of learning inevitably be influenced by their peers or teachers (Liu, 2005). Thus, a good learning environment offering students opportunities to communicate and learning corporately will be beneficial to help students establish and develop conceptions like “applying”.

5. Conclusion

The current research first explored the factorial structures of high school students’ conceptions of learning English, and eight categories of conceptions of learning were identified. They are “Meeting the requirements”, “Memorizing”, “Testing”, “Drills and practice”, “Increasing one’s knowledge”, “Applying”, “Understanding”, and “Seeing in a new way”. Qualitative data were further analyzed to explore major factors affecting students’ conceptions of learning English. Finally, four factors were identified, including learning experience, discipline-based learning content, classroom teaching, and school culture. The qualitative results provided positive implications for guiding high school students to establish appropriate conceptions of learning English. First, it’s possible to guide students to change their conceptions of learning English by changing their learning experience. Second, it’s advised that English instructors should choose suitable teaching materials with appropriate difficulty and interesting content to stimulate students’ interest in learning English. Besides, it’s very important that English teachers should pay attention to their professional skills training and development and establish appropriate conceptions of learning English first. Finally, it’s essential to create a good learning environment with pleasant atmosphere and rich opportunities to communicate to help guide students to establish sophisticated conceptions of learning English.

Acknowledgements

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References


High School Students’ Online Engagement During the Covid-19 Pandemic in China

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Abstract: In order to prevent and control the negative effect of Covid-19 pandemic on education in China, schools at different levels were encouraged to adopt online teaching to ensure school education in good orders. This study aims to investigate high school students’ online engagement during the Covid-19 pandemic in an online English course offered to Changshun Senior High School of Nationalities in China. The participants were 287 senior high school students from this school who took online English courses during the pandemic. Both quantitative and qualitative data were collected based on the online engagement of learning English (OELE) survey. An exploratory factor analysis was conducted to establish the factor structure of the high school students’ online engagement and the qualitative data were further analyzed. The quantitative results indicated that learners’ engagement of learning English in the online environment included four factors, namely cognitive engagement, behavioral engagement, emotional engagement, and social engagement. The qualitative results showed that teachers’ supervision and online management during online courses are important factors affecting high school students’ online engagement. Most of the students expected more supervision and interaction when learning online. Particularly, more question-and-answer sessions and group discussions could be designed for online courses. This study also showed the significance of reinterpreting students’ online engagement in ethnic minority regions, which can be a significant prerequisite for online language learning.

Keywords: online engagement; high school students; ethnic minority regions

1. Introduction

In order to prevent and control the negative effect of Covid-19 pandemic on education in China, the Ministry of Education issued the policy of “suspension of school and no suspension of learning” to the whole country. Following the policy, schools at different levels actively carried out online courses and the online learning ensured students’ learning progress during the prevention and control period of the pandemic. Students’ engagement in online courses and whether these courses meet their expectations are important prerequisite for the quality of online programs. This study aims to investigate high school students’ online engagement during the Covid-19 pandemic in the setting of online English courses offered to Changshun Senior High School of Nationalities in China.

2. Literature Review

2.1 Student engagement

The concept of “student engagement” appeared around 70 years ago. In the 1930s, educational psychologist Ralph Tyler conducted a study at the University of Ohio and the University of Chicago to investigate the amount of time and effort students spent on school work (Wang, 2013). In 2004, Jennifer Fredricks and his fellows proposed that the meta-structure of student engagement includes behavioral, emotional and
cognitive engagement. The research construct of student engagement was investigated in different contexts
(such as in the classrooms, during after-class activities or out-of-school situations) and under different
theoretical frameworks. Extensive research has been conducted on the measurement of student engagement
in earlier literature (e.g., Betts et al, 2010; Carle et al, 2009; Carter et al, 2012; Fredricks, 2004, 2016; Hazel
et al, 2014; Henrie et al, 2015; Whitney et al, 2019). How engagement predicts outcomes in terms of
psychological states, ability or academic achievement (e.g., Lei et al. 2018; Gunuc, 2014; Villiers &
Werner, 2018; Wu & Wu, 2020), and how internal or external factors influences student engagement (e.g.,
Huang et al., 2019; Maguire et al., 2017; Virtanen et al., 2015; Wang & Eccles, 2012, 2013) were the
mainstream topics during the past decade. In addition, the structural relations among behavioral, cognitive
and emotional engagement also drew researchers’ attention in recent years (e.g., Hong, 2020; Gunuc, 2015).

2.2 Online engagement

With the rapid development of a variety of scientific technologies, researchers started to focus on students’
online engagement (Ding et al, 2017; Gupta & Pandey, 2018; Wang et al, 2016). Students’ online engagement
refers to behavioral engagement, cognitive engagement and emotional engagement when learning online
(Hu et al, 2016). During these years, many studies focused on students’ online engagement or engagement
in distance education (e.g., Gupta & Pandey, 2018; Rienties et al., 2018; Sun & Rueda, 2012; Wang, 2016).
Several studies also paid attention to how social medias such as Facebook or Tweets influence student
engagement (e.g., Faizi, 2019; Junco et al, 2010; Junco, 2012).

In general, existing studies rarely paid attention to high school English language learners’ online
engagement. In order to explore the above issues, this study focuses on high school students’ online
engagement during the Covid-19 pandemic. The research aims at answering the following two questions:
(1) What are the factorial structures of high school students’ online engagement of English language
learning during the Covid-19 pandemic?
(2) How do high school students perceive their online engagement of English language learning during the
Covid-19 pandemic?

3. Methodology

3.1 Research Context

The present study was conducted during the Covid-19 pandemic in China among the students in Changshun
Senior High School of Nationalities of Guizhou Province in China. Students took the online English course
regularly four times every week on the designated online platforms such as Tencent Conference (9.76%),
Dingding (20.21%), E-Net (53.66%), SkyQian (87.11%), Wechat/QQ (8.01%) and other online platforms
(8.71%). Nearly all students took online courses using cellphones (73.17%) and televisions (20.91%). They
also took online courses through tablets (3.48%), computers (0.35%) and other equipment (2.09%).

3.2 Participants

A total of 287 English language learners of this course participated in the study, including 145 males and
142 females, with an average age of 17 years old. 190 of them were ethnic minority students and 97 were
Han students. The 287 EFL learners were invited to complete the survey. 79.44% of them took their first
online course in 2020 and only 20.56% of them took their first online courses in 2019 or earlier.

3.3 Instrument

This research employed a questionnaire to explore the high school students’ online engagement of learning
English (OELE) during the Covid-19 pandemic in China. This questionnaire was adapted from a
questionnaire developed by Wang et al. (2016), which was designed to measure students’ math and science engagement. It is a valid and reliable instrument and the questionnaire items were measured with a five-point Likert scale, from 1 “do not agree at all” to 5 “strongly agree”. Since English is a foreign language for the participants, all the items in the questionnaire were translated into Chinese. The questionnaire items were modified by changing the statements to more specifically target at online English language learners. This questionnaire was developed to investigate students’ four dimensions of online engagement including cognitive engagement (CE), behavioral engagement (BE), emotional engagement (EE) and social engagement (SE). Under each dimension there are five items. In order to better understand learners’ perceptions of their online engagement, the survey also included two open-ended questions.

3.4 Data Collection and Analysis

Both quantitative and qualitative data were collected through the survey. A total of 287 participants in the study volunteered to respond to the questionnaires online. The students’ responses to the questionnaire were further analyzed. The quantitative data were processed with SPSS 25.0 and an exploratory factor analysis (EFA) was conducted to establish the factor structure of high school students’ online engagement. The qualitative data were collected based on students’ answers to the open-ended question: “During this Covid-19 pandemic, what is your most satisfied and dissatisfied experience by learning English online?” And the qualitative data were transcribed into English in this paper.

4. Results

4.1 Quantitative Results

The exploratory factor analysis (EFA) was used to analyze the quantitative data. The principle component analysis was used as the extraction method, and Varimax with Kaiser Normalization as the rotation method (Kaiser, 1958). And the rotation was convergent after 7 iterations. Table 1 shows the results of the exploratory factor analysis for the instrument. As a result, a total of 19 items and four factors were retained in the final version of it. Factor loading of each factor is over 0.50 and the reliability coefficient of each dimension is over 0.80. The total variance explained is 68.54%. as Table 1 shows, the four factors were “Cognitive engagement (CE)” (α = 0.85, Mean = 3.42, S.D. = 0.60), “Emotional engagement (EE)” (α = 0.86, Mean = 3.40, S.D. = 0.70), “Social engagement (SE)” (α = 0.84, Mean = 3.42, S.D. = 0.63) and “Behavior engagement (BE)” (α = 0.89, Mean = 3.50, S.D. = 0.65). The alpha coefficient of this study was around 0.60-0.70 for each factor (overall alpha = 0.90), indicating that the internal consistency was sufficient for statistical analysis.

<table>
<thead>
<tr>
<th>Factor 1: CE</th>
<th>Factor 2: EE</th>
<th>Factor 3: SE</th>
<th>Factor 4: BE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE1</td>
<td>0.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CE2</td>
<td>0.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CE3</td>
<td>0.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CE4</td>
<td>0.64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factor 2: EE</td>
<td>0.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EE5</td>
<td>0.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EE6</td>
<td>0.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EE7</td>
<td>0.78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EE8</td>
<td>0.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EE9</td>
<td>0.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factor 3: SE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factor 4: BE</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Rotated factor loadings and Cronbach's alpha values for the four factors of the instrument (n=287)
<table>
<thead>
<tr>
<th>SE10</th>
<th>0.56</th>
</tr>
</thead>
<tbody>
<tr>
<td>SE11</td>
<td>0.66</td>
</tr>
<tr>
<td>SE12</td>
<td>0.76</td>
</tr>
<tr>
<td>SE13</td>
<td>0.58</td>
</tr>
<tr>
<td>SE14</td>
<td>0.71</td>
</tr>
<tr>
<td>SE15</td>
<td>0.69</td>
</tr>
</tbody>
</table>

Factor 4: Behavior engagement (BE), $\alpha = 0.89$, Mean = 3.50, S.D. = 0.65

<table>
<thead>
<tr>
<th>BE16</th>
<th>0.56</th>
</tr>
</thead>
<tbody>
<tr>
<td>BE17</td>
<td>0.76</td>
</tr>
<tr>
<td>BE18</td>
<td>0.65</td>
</tr>
<tr>
<td>BE19</td>
<td>0.66</td>
</tr>
</tbody>
</table>

Note. Overall alpha: 0.90; total variance explained: 68.54%.

### 4.2 Qualitative Results

#### 4.2.1 High School Students’ Positive Perceptions of Online Learning Engagement

Students were invited to report their most satisfied and dissatisfied experience when learning online. Then, we explored their online engagement based on their descriptions. As indicated by their answers, most students had little web-based learning experience before the epidemic. It is obvious that a majority of the students perceived learning English online quite novel and rather relaxed. By conducting in-depth analysis on their response to open-ended question, several categories of their online engagement were revealed.

**R(researcher):** What is your most satisfied English learning engagement experience during the Covid-19 pandemic?

For the cognitive engagement, students who took their first online courses in 2020 considered it a good way for self-regulated English language learning. It’s more convenient for them to get information and useful knowledge that they needed. Smart phones and the high-speed Internet connection in Guizhou also ensured their English learning online. Students can study independently at any time and any place. Students also claimed that instructors from pioneering high schools with better qualifications provided high quality online English courses.

**S1:** It’s rather new and novel for me to have online courses. I had dreamed of studying at home or on my bed. And it had come true.

**S2:** It’s convenient for me to take notes and review what the teacher had taught, since I can replay as many courses as I like.

**S3:** Web-based learning offered me more learning channels and made it faster to get knowledge and information that I needed.

**S4:** I can communicate with teachers directly at home online.

**S5:** I acquired more learning strategies through online learning.

**S6:** It provided me with more chances to experience other outstanding teachers’ courses, and get more new knowledge.

**S7:** It was a way worth promoting in the future.

**S8:** More useful learning content were provided.

**S9:** I think it’s better than offline courses, mainly because of the improvement of quality, quantity, teaching methods and the learning environment.

**S10:** Teachers prepared the courses carefully and the courses covered more relative language knowledge.

For the emotional engagement, students can enjoy a more comfortable environment without the pressure from teachers and peer students. And students found it easier and more confident to answer
questions during online courses as they would not be embarrassed or feel shameful if they didn’t get the right answer.

S1: I felt less stressed than I did in offline courses. I was more relaxed and confident.
S2: I felt free.
S3: I was much happier and more interested in online learning.

For the behavioral engagement, online courses required students to accomplish all the learning tasks independently. As a result, students should be more careful and self-regulated when studying at home.

S1: It was a good chance to improve my self-regulated language learning.
S2: Studying online facilitated my self-discipline in English language learning.
S3: I can study independently without time and place constrain. Learning online was quieter and more private compared to offline courses.
S4: I listened more attentively during learning English online.

Table 2. Students’ Positive Perceptions of Online Learning Engagement Experience

<table>
<thead>
<tr>
<th>Categories</th>
<th>Sub-categories</th>
<th>Sample Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive</td>
<td>Novelty</td>
<td>It’s rather new and novel for me to have online courses.</td>
</tr>
<tr>
<td></td>
<td>Convenience</td>
<td>It’s convenient for me to take notes and review what the teacher had taught.</td>
</tr>
<tr>
<td></td>
<td>Effectiveness</td>
<td>More useful learning content were provided.</td>
</tr>
<tr>
<td></td>
<td>High-quality for knowledge</td>
<td>I think it’s better than offline courses, mainly because of the improvement of quality.</td>
</tr>
<tr>
<td></td>
<td>acquiring</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Variety for using cognitive</td>
<td>I acquired more learning strategies through online learning.</td>
</tr>
<tr>
<td></td>
<td>strategies</td>
<td></td>
</tr>
<tr>
<td>Emotional</td>
<td>Comfort and confidence</td>
<td>I felt less stressed than I did in offline courses. I was more relaxed and confident.</td>
</tr>
<tr>
<td></td>
<td>Happiness and interest</td>
<td>I was much happier and more interested in online learning.</td>
</tr>
<tr>
<td></td>
<td>Freedom</td>
<td>I felt free.</td>
</tr>
<tr>
<td>Behavioral</td>
<td>Self-regulation</td>
<td>It’s a good chance to improve my self-regulated language learning.</td>
</tr>
<tr>
<td></td>
<td>Independence</td>
<td>I can study independently without time and place constrain.</td>
</tr>
<tr>
<td></td>
<td>Concentration</td>
<td>I listened more attentively during learning English online.</td>
</tr>
</tbody>
</table>

In a word, students generally had positive perceptions towards their online learning engagement in cognitive, emotional and behavioral aspects. Most students enjoyed the online learning courses and felt free in terms of time and place. The flexibility of online learning and the less stressful atmosphere made them feel more comfortable and relaxed. Moreover, online learning also improved their self-regulation, independence, and concentration.

4.2.2 High School Students’ Negative Perceptions of Online Learning engagement

Students expected to improve their language learning in online courses, but they also had some negative perceptions of their learning engagement. More unexpectedly, some students who studied online were more likely to choose offline courses if permitted. They claimed that there were more interaction and peer co-operations in offline courses.

R(researcher): What is your most dissatisfied English learning experience during the Covid-19 pandemic?

For the cognitive engagement in online courses, some students with poor English language level found that it was not easy for them to be fully involved in the courses, on account of the relatively more difficult contents of online courses. In addition, students found it was a big challenge for them to apply what the teacher had taught, although students thought they had understood the learning contents. They
considered it inconvenient to hand in assignments and hard to get timely feedback from the teachers. Moreover, poor Internet connections or network jams also added to the negative perceptions of students.

S1: The content was difficult for me.
S2: I can understand what I had learned in class, but it seemed rather difficult for application.
S3: It’s not convenient for us to hand in assignments through the Internet.
S4: In the online courses, there’s no time for students to think deeply and independently.
S5: I can’t follow the teachers as they spoke English during the whole class.
S6: The network was not always smooth and the software sometimes cannot be connected.
S7: I wished to watch online courses with high resolution.
S8: I needed to do a lot of note. As a result, I missed some important points.

For the emotional engagement, students whose English proficiency was relatively low felt less enjoyable to be involved in online courses.

S1: I felt happy, but anxious at the same time.
S2: I felt bored.

For the behavioral engagement, students failed to self-regulate their English language leaning well enough as the they had expected.

S1: I can’t conduct self-regulated learning well.
S2: I can’t concentrate on the course all the time. I always wanted to play games or do other things on my cellphone.

For the social engagement in online courses, students claimed that they had great demand of active discussions and interaction with teachers and classmates. Students highlighted the negative influence of being lack of teachers’ supervision. Less self-regulated students expected to be supervised by teachers in online courses.

S1: The course lacking interaction failed to offer an authentic English language learning environment.
S2: I can’t communicate with others and my teacher at any time when I had problems.
S3: Teachers didn’t have a good observation of students’ learning.
S4: Without the teacher’s supervision, the learning outcome was not as good as I expected.
S5: I can’t discuss with classmates. Learning was less active than offline courses at school.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Sub-categories</th>
<th>Sample Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive</td>
<td>Difficulty in content</td>
<td>The content was difficult for me.</td>
</tr>
<tr>
<td></td>
<td>Difficulty in application</td>
<td>I can understand what I had learned in class, but it seemed rather difficult for application.</td>
</tr>
<tr>
<td></td>
<td>Inconvenience</td>
<td>It’s not convenient for us to hand in assignments through the Internet.</td>
</tr>
<tr>
<td></td>
<td>Fast pace of teaching</td>
<td>I can’t follow the teachers as they spoke English during the whole class.</td>
</tr>
<tr>
<td>Emotional</td>
<td>Anxiety</td>
<td>I felt happy, but anxious at the same time.</td>
</tr>
<tr>
<td></td>
<td>Boredom</td>
<td>I felt bored.</td>
</tr>
<tr>
<td>Behavioral</td>
<td>Poor self-regulation</td>
<td>I can’t conduct self-regulated learning well.</td>
</tr>
<tr>
<td></td>
<td>Poor interaction</td>
<td>The course lacking interaction failed to offer an authentic English language learning environment.</td>
</tr>
<tr>
<td></td>
<td>Poor supervision</td>
<td>Without the teacher’s supervision, the learning outcome was not as good as I expected.</td>
</tr>
</tbody>
</table>
Inactiveness  I can’t discuss with classmates. Learning was less active than at school.

Students claimed their great demand for interaction and supervision from instructors in online courses. And online courses lacking interaction and supervision can’t meet students’ expectations. It seemed difficult to organize synchronous and immediate interaction as the online courses were recorded ahead of time. In addition, students tended to be poor self-regulated during online learning, thus, better management and instructions from schools and teachers during online courses seemed to be of great significance to improve students’ learning.

5. Discussion

5.1 High school students’ online engagement

In this inquiry, the OELE survey was developed to investigate the factorial structures of high school students’ online engagement of their English language learning during the Covid-19 pandemic. The findings through exploratory factor analysis indicated that learners’ engagement of learning English in the online environment included four factors, namely cognitive engagement, behavioral engagement, emotional engagement, and social engagement. The instrument displayed similar factor structures as revealed by former studies which supported learner engagement as a multidimensional construct (Reschly & Christenson, 2012; Wang & Degol, 2014), and it showed satisfactory alpha reliability. The instrument validated in this research could assist instructors and researchers to gain an overall understanding of learners’ online engagement of learning English.

The results of this study demonstrated that learner engagement consisted of four theoretically distinct dimensions, and did not support recent research to regard learner engagement as a continuum (Sinatra et al., 2015). The multidimensional perspective of learner engagement provided a richer characterization of how learners behave, think, feel, and socialize with others during online learning, rather than exploring each of the dimensions separately (Wang et al., 2016). In this study, learners generally had positive engagement in learning English in the online environment.

5.2 High school students’ perceptions of online engagement

Both quantitative and qualitative results indicated that online course during the Covid-19 pandemic generally met students’ expectations. A majority of the students enjoyed online courses as it provided them with independent learning experience without time and place constrain. The flexibility and the less stressful atmosphere can be considered as the positive aspects of online courses. However, students from less developed areas with poor Internet connections and low information literacy, or those who have a poor command of English generally showed negative perceptions of online English language learning. This may be due to their lack of appropriate training for online learning.

Therefore, more personalized and well-planned online courses, including more interaction and specific instructions were expected by most of the students. Accordingly, to engage students in online learning and improve the quality of online programs, we suggest that schools should continue to improve the curriculum content, quality, as well as construction of online teaching platforms. The instructors should make use of various strategies to facilitate learning and actively engage students in online courses. High school students should improve their adaptability to new media learning, develop good learning habits, and improve their independent learning ability.

6. Conclusion
This study investigated students’ online engagement during the Covid-19 pandemic. Quantitative results indicated that learners’ engagement of learning English in the online environment included four factors, namely cognitive engagement, behavioral engagement, emotional engagement, and social engagement. Findings through qualitative research suggested that most learners generally had positive engagement in learning in the online environment. Students had positive perceptions of online learning engagement in cognitive, behavioral and emotional aspects. And the flexibility and the less stressful atmosphere made them feel more comfortable and relaxed. Moreover, online learning also improved their self-regulation, independence, and concentration. Negative perceptions were described in cognitive, emotional, behavioral and social aspects. Students mostly claimed their great demand of interaction and supervision from instructors in online courses. And the lack of interaction and supervision led to the reduced positive effect of online courses on English language teaching. In addition, online management was also an important factor affecting high school students’ online engagement. This study also showed the significance of reinterpreting students’ online engagement in less developed areas, which can be a significant prerequisite for online language learning. A further study can be conducted to explore the structural relations among the different dimensions of students’ online engagement to facilitate students’ online learning in ethnic minority regions in the future.

Acknowledgements

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References


Exploring Junior High School Students’ Online Self-Regulation During the Covid-19 Pandemic in China

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Abstract: This mixed-methods study explored junior high school students’ online self-regulation during the covid-19 pandemic in China. Total of 229 students in a junior high school were invited. Data were collected from Online Self-regulated English Learning questionnaire and eight open-ended questions. Firstly, the exploratory factor analysis was conducted to study the factorial structures of learners’ online self-regulation. The quantitative results shown that learners’ online self-regulation involved five factors: goal setting, environment structuring, task strategies and time management, help seeking and self-evaluation. Secondly, the content analysis of eight open-ended questions was conducted to explore learners’ expectations for ideal online English language learning. The qualitative results indicated these five factors of online self-regulation played a critical role in learners’ ideal online English language learning. This study provided several implications for language teaching instructors on effective use of technologies. It also offered suggestions for designing more effective online English language courses for supporting learners’ online self-regulatory learning.

Keywords: online self-regulation, junior high school students, the Covid-19 Pandemic, mixed-method study

1. Introduction

The global spread of Covid-19 in 2020 has caused suspension of regular teaching of schools around the world. It has caused the situation of “separation of teachers and students”, “separation of teachers and schools”, “separation of students and schools”, and “separation of students and students” in education (Li & Zhang, 2020). In China, Ministry of Education proposed online education to cope with the extreme situations caused by the epidemic. It spawned the rapid popularization of online education in the form of live or on demand (Yu & Wang, 2020). During the covid-19 pandemic, better organized online courses were required for English language instructors and English language learners were put a high demand on self-regulated learning ability. For junior high school students, since their cognitive and metacognitive competences have not been fully developed like adults. Effective self-regulated learning skills were more critical for their online English language learning in such a special period. Thus, it was very urgent and necessary to explore junior high school students’ online self-regulation. This study aimed to explore the factorial structures of junior high school students’ online self-regulation during the covid-19 pandemic and further explored their expectations for ideal online English language learning, hoping to help teachers and students better deal with the learning dilemma under extreme situations, and provide some implications for English language instructors to design well-developed courses and have a deeper understanding of junior high school students’ online self-regulation in special periods such as epidemic prevention and control. This study was guided by the following two research questions:

1. What are the factorial structures of junior high school students’ online self-regulation of their English language learning during the covid-19 pandemic?
2. What are students’ expectations for their ideal online English language learning?
2. Literature Review

2.1 Self-regulation

Self-regulation is a crucial research construct in the educational psychology and second language acquisition (SLA) area (e.g., Rose & Harbon, 2013; Tseng, Chang, & Cheng, 2015; Tseng, Dörnyei, & Schmitt, 2006). It is regarded as a multidimensional and process-oriented research construct (Bown & White, 2010; Dörnyei, 2005; Dörnyei & Ryan, 2015). According to Zimmerman and Kitsantas, self-regulation refers to “processes that learners use to activate and maintain cognitions, emotions, and behaviors to attain personal goals” (Zimmerman & Kitsantas, 2014, p. 145). Previous studies have identified its influences on learners’ learning engagement, learning achievements and their lifelong learning skills (Bai, 2018; Dignath, Büttner, & Langfeldt, 2008; Hromalik & Koszalka, 2018).

2.2 Online Self-regulation

The development and application of technologies in education settings drives the transformation of learners’ learning environments (e.g., Chen Hsieh, Huang, & Wu, 2017; Liaw, 2015). It also provided further opportunities for learners to conduct self-regulated learning in online or blended learning environments (Barnard, Lan, To, Paton, & Lai, 2009; Zheng, Liang, Yang, & Tsai, 2016). Barnard et al. designed the Online Self-regulated Learning Questionnaire (OSLQ) to explore learners’ online self-regulation from six dimensions, namely, goal setting, time management, environment structuring, help seeking, task strategies, and self-evaluation (Barnard et al., 2009). Several subsequent studies have explored learners’ self-regulation in online or blended learning environments (e.g., Zheng et al., 2016; Su, Zheng, Liang, & Tsai, 2018). During the covid-19 pandemic, English language learners demanded higher self-regulated learning skills. This study aimed to explore the factorial structures of junior high school students’ online self-regulation during the covid-19 pandemic and further explored their expectations for ideal online English language learning.

3. Research Methods

3.1 Research Context and Participants

The study was conducted in an online English class at a junior high school in Hangzhou city of Zhejiang province in China. During the covid-19 pandemic, this school followed the advocation of Ministry of Education to conduct online education. Total of 229 junior high school students were invited to participate in the study. There were 135 students from third year of junior high school and 35 from second year (124 males, 105 females). They aged from 14 to 15 years old. The majority of them were the children of migrant workers from three relatively underdeveloped provinces, Jiangxi, Anhui and Henan, while just few of them were local registered. They were left-behind children who lived with their grandparents in the early years of primary school or were even entrusted to their relatives or parents’ friends. Therefore, their English language proficiency is at the beginning level. However, schools in Hangzhou city all use the Go for IT textbook which requires students to have four-year English language learning experience at least. As a result, it is relatively difficult for those beginning-level students who almost had no English language learning experience in their hometown.

3.2 Data Collection

This study employed Online Self-regulated English Learning (OSEL) and eight open-ended questions to explore junior high school students’ online self-regulation during the covid-19 pandemic and probe their ideal online English language learning. The questionnaire was adapted from Online Self-regulated Learning
Questionnaire (OSLQ) developed by Barnard et al. (2009) by changing the statements to more specifically target online English language learners. It was a five-point Likert scale questionnaire and were measured from 1 “do not agree at all” to 5 “strongly agree”. Eight open-ended questions were employed to probe learners’ ideal online English language learning like “During the covid-19 pandemic, when you learned English online, what are your most satisfied learning experiences?” and “What is your ideal online English course?”. Since English is a foreign language for the participants, all the questionnaires items and open-ended questions were translated into Chinese.

3.3 Data Analysis

First of all, exploratory factor analysis was used to test the construct validity of the OSEL questionnaire and explore the factorial structures of junior high school students’ online self-regulation. And then content analysis was used to analyze the open-ended questions and probe these learners’ ideal online English language learning. SPSS 24.0 and NVivo 11.0 were used in data analysis process.

4. Results and Discussion

4.1 Exploratory Factor Analysis of the OSEL Questionnaire

Table 1 showed the exploratory factor analysis results for the OSEL questionnaire. The principal component analysis was utilized as the extraction method, with the rotation method of varimax with Kaiser normalization (Kaiser,1958). The factor loading of items should preferably larger than 0.4 in the relevant scale and smaller than 0.4 in the non-relevant scale (Stevens, 1996). As a result, 15 items were retained and further grouped into five factors in the final version of the OSEL, with a total of 82.19% of variation explained. First, four factors were maintained in the final OSEL, namely “Goal setting (GS)” (α = 0.90, Mean = 3.57, S.D. = 0.80), “Environment structuring (ES)” (α = 0.90, Mean = 3.93, S.D. = 0.70), “Help seeking (HS)” (α = 0.90, Mean = 3.77, S.D. = 0.79) and “Self-evaluation (SE)” (α = 0.90, Mean = 3.60, S.D. = 0.85). Then, the two factors “Task strategies” and “Time management” were combined into one factor as “Task strategies and time management (TSTM)” (α = 0.84, Mean = 3.88, S.D. = 0.69). The alpha coefficient of this study was around 0.84-0.90 for each factor (overall alpha = 0.94), indicating satisfactory internal consistency of assessing students’ online self-regulated English learning. The results were consistent with previous studies on learners’ online self-regulation (e.g., Barnard et al., 2009; Zheng et al., 2016).

Table 1. Rotated Factor Loadings and Cronbach’s $\alpha$ Values for The Five Factors of the OSEL

<table>
<thead>
<tr>
<th>Factor 1: Goal setting (GS), $\alpha$ = 0.90, Mean = 3.57, S.D. = 0.80</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.81</td>
</tr>
<tr>
<td>0.76</td>
</tr>
<tr>
<td>0.73</td>
</tr>
<tr>
<td>Factor 2: Environment structuring (ES), $\alpha$ = 0.90, Mean = 3.93, S.D. = 0.70</td>
</tr>
<tr>
<td>0.84</td>
</tr>
<tr>
<td>0.80</td>
</tr>
<tr>
<td>0.77</td>
</tr>
<tr>
<td>Factor 3: Task strategies and time management (TSTM), $\alpha$ = 0.84, Mean = 3.88, S.D. = 0.69</td>
</tr>
<tr>
<td>0.78</td>
</tr>
<tr>
<td>0.78</td>
</tr>
<tr>
<td>0.73</td>
</tr>
<tr>
<td>0.59</td>
</tr>
<tr>
<td>Factor 4: Help seeking (HS), $\alpha$ = 0.90, Mean = 3.77, S.D. = 0.79</td>
</tr>
<tr>
<td>0.82</td>
</tr>
<tr>
<td>0.77</td>
</tr>
<tr>
<td>0.75</td>
</tr>
<tr>
<td>Factor 5: Self-evaluation (SE), $\alpha$ = 0.90, Mean = 3.60, S.D. = 0.85</td>
</tr>
<tr>
<td>0.83</td>
</tr>
<tr>
<td>0.77</td>
</tr>
</tbody>
</table>
4.2 Junior High School Students' Ideal Online English Language Learning

Through content analysis of the open-ended questions, learners’ ideal online English language learning were identified. The results shown that five factors of online self-regulation played a critical role in junior high school students’ ideal online English language learning during the covid-19 pandemic.

As shown in Table 2, first of all, students emphasized the importance of goal setting in the online English language learning process. They hoped to set performance, homework and learning standards when they learn English online. As Zheng and her colleague’s findings (2012), learning goals are the main source of learners’ learning motivation. During the covid-19 pandemic, online self-regulated learning would provide learners with more learning requirements and opportunities. As a result, teachers should pay attention to train learners to set long-term language learning goals, and to assist them to set more reasonable learning requirements and homework standards, especially for junior high school students.

Secondly, learning environments structuring had a direct impact on learner’s online English language learning. Students hoped that they can learn English in a relatively quiet environment, not been disturbed by the surrounding environments. What’s more, during the covid-19 pandemic, online learning was implemented by schools around the country. Learners asserted fast and stable internet connection can be provided, so they could concentrate on studying and improved learning efficiency. When they are learning online, learners also hope they can speak freely on the platform and they can communicate with the teacher and classmates more conveniently. Anderson et al. revealed that learning environment is crucial components of learning system (2017). During the special time, more well-structured learning environments played a more critical role on learners’ effective online English language learning.

Thirdly, in the process of online language learning, learners proposed that task strategies and time management were important factors affecting their learning. During online English language learning process, replaying of class recordings provided learners an agency for effective language learning. What’s more, since the students all learned English language online at home, their time management ability on and beyond class and self-control ability should be enhanced. Teacher supervision should also be strengthened because junior high school students were less of self-control ability in a certain degree than university students or adults. Learners’ effective use of task strategies and time management are critical factors of their language learning (Qiu, Liu, & Xiao, 2008). During the covid-19 pandemic, learners’ learning strategies and effective use of time are of great importance to their English language learning.

Fourth, learners proposed that help seeking was one of the critical factors in their ideal online English language learning. During the covid-19 pandemic, when learners had problems, they tended to solve it through watching teaching recordings or searching on the internet. It was consistent with the Vincent et al.’ findings (Vincent, Elmar, Silke, Frank, & Raven, 2003). As a result, teachers should provide learners with more useful and well-developed learning materials to enhance learners’ effective online English language learning.

Lastly, self-evaluation was of great importance to learners’ ideal online English language learning. Learners’ role of evaluation and assessment should be fully developed in the new curriculum reform (Sun, 2016). Self-evaluation could help learners identify the gap between themselves and their classmates and understand their own shortcomings, and then help them become independent lifelong learners (Hung, 2019).

As the results of qualitative findings, five factors of online self-regulation played a critical role in junior high school students’ expectations for ideal online English language learning. During the covid-19 pandemic, effective online self-regulation might promote learners’ language learning achievements. In particular, compared with traditional learning in schools, learners emphasized the importance of quiet environments and fast Internet connection for their language learning. Replaying teaching recordings was also one of the beneficial strategies for them. During the special periods, learners’ online self-regulation is a challenge but also an opportunity for language learners. For English language instructors, in-depth understanding of learners’ online self-regulation mechanism is an opportunity to further design well-
developed English language courses and provide ideal online English language learning environments for language learners.

Table 2. Learners’ Expectations for Ideal Online English Language Learning

<table>
<thead>
<tr>
<th>Categories</th>
<th>Sub-categories</th>
<th>Frequency</th>
<th>Sample statements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Goal setting</strong></td>
<td>Setting performance standards</td>
<td>125</td>
<td>“I could motivate myself to learn and be aware of the gap between my classmates and me.”</td>
</tr>
<tr>
<td></td>
<td>Having learning requirements</td>
<td>40</td>
<td>“I learned to make learning plans.”</td>
</tr>
<tr>
<td></td>
<td>Setting homework standards</td>
<td>35</td>
<td>“I could consciously complete the homework.”</td>
</tr>
<tr>
<td><strong>Environment structuring</strong></td>
<td>Fast internet connection</td>
<td>162</td>
<td>“I am always stuck on the internet.”</td>
</tr>
<tr>
<td></td>
<td>Quiet environment</td>
<td>110</td>
<td>“I like learning at home, because I could not be disturbed.”</td>
</tr>
<tr>
<td></td>
<td>Effective communication</td>
<td>49</td>
<td>“Sometimes the class was silent and not active as previous class in school.”</td>
</tr>
<tr>
<td><strong>Task strategies and Time management</strong></td>
<td>g</td>
<td>125</td>
<td>“The class recordings could be replayed. I could take screenshots and take notes after class.”</td>
</tr>
<tr>
<td></td>
<td>Managing time</td>
<td>81</td>
<td>“Less time on the way to go to school and more time to study.”</td>
</tr>
<tr>
<td></td>
<td>Being good at self-control</td>
<td>78</td>
<td>“Poor self-control leaded to poor learning achievements.”</td>
</tr>
<tr>
<td></td>
<td>Teacher supervision</td>
<td>31</td>
<td>“It was not very effective without a teacher’s supervision.”</td>
</tr>
<tr>
<td></td>
<td>Using the time after class</td>
<td>26</td>
<td>“If I did not understand or miss something, I could look back again and again.”</td>
</tr>
<tr>
<td><strong>Help seeking</strong></td>
<td>Watching teaching recordings</td>
<td>74</td>
<td>“When I did not understand something, I repeatedly watched the teaching recordings.”</td>
</tr>
<tr>
<td></td>
<td>Searching on the Internet</td>
<td>37</td>
<td>“I learned to surfing the Internet for information.”</td>
</tr>
<tr>
<td></td>
<td>Asking teachers and classmates for help</td>
<td>29</td>
<td>“If I did not understand something, I could ask classmates for help.”</td>
</tr>
<tr>
<td><strong>Self-evaluation</strong></td>
<td>Summarizing learning outcomes</td>
<td>56</td>
<td>“Studying online allowed me to broaden my horizons and improve my grades.”</td>
</tr>
<tr>
<td></td>
<td>Identifying shortcomings</td>
<td>27</td>
<td>“I could know my shortcomings according to the notes that my teacher wrote on my homework.”</td>
</tr>
</tbody>
</table>

5. Conclusion

This study explored junior high school students’ online self-regulation during the covid-19 pandemic in China. The quantitative results shown that learners’ online self-regulation involves five factors: goal setting, environment structuring, task strategies and time management, help seeking and self-evaluation. The
qualitative results indicated these five factors played a critical role in learners’ ideal online English language learning. This study might provide some implications for language teaching instructors. Firstly, during the special time of covid-19 pandemic, English language teachers should fully consider how to make use of technologies to design effective online English language courses. Secondly, considered the great importance of factors of online self-regulation on learners’ online language learning, teachers are advised to better understand students’ online self-regulatory mechanisms and provide more timely and appropriate guidance to help them have ideal online English language learning (Kuo, Walker, Schroder, & Belland, 2014).

Acknowledgements

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References


Yu, S., & Wang, H. (2020). How to better organize online learning in extreme situations such as epidemics. China Educational Technology, (400), 6-14+33.
Research on TPACK and Teacher Professional Development of Secondary Physical Education Pre-service Teachers

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Abstract: The main purpose of this study was to explore the relationships between teachers’ Technological Pedagogical Content Knowledge (TPACK) and their Teacher Professional Development (TPD). A total of 305 secondary physical education pre-service teachers (S-PEPT) participated in this study. In this study, two questionnaires, TPACK and TPD, were used. As a result, the confirmatory factor analysis showed that the two questionnaires used in this study were valid and reliable. In addition, S-PEPT’s TPACK highly correlated with their TPD. Finally, according to path analysis, the result indicated that S-PEPT’s PCK and TCK could significantly predict their TPD. The implication of this study showed that S-PEPT with more knowledge of IT-assisted teaching may therefore increase the IT usage in the classroom, and then have more competencies to face the diverse students and environment of the 21st century.

Keywords: Teacher Professional Development, Physical Education Pre-service Teachers

1. Introduction

1.1 TPACK of PE (Physical Education)

With the rapid development of technology applications, it has become a basic quality that teachers teaching should use now. Facing the new opportunities and impacts brought by information technology and the internet to education, teachers in the 21st century should not only possess content knowledge (CK) and pedagogy knowledge (PK), but also could apply technology knowledge (TK) to enhance students' learning effectiveness.

In order to help teachers effectively combine the CK, PK and TK in the teaching process, and solve the complex teaching activities that may be faced with, Mishra and Koehler (2006) further proposed technological pedagogical and content knowledge (TPACK) based on pedagogic content knowledge (PCK).

The practical application of the integration of technology into physical education has been quite common. Compared with other disciplines, physical activity has the peculiarities of physical activity, and the nature of its teaching methods is quite different from other disciplines. Therefore, technology-assisted physical education not only breaks the barriers of traditional physical education classrooms, but also extends the infinite horizon and space of physical education teaching, helping learners improve their learning motivation, and promote learners' learning effectiveness (Pasco, 2013; Semiz & Ince, 2012).

This shows the importance of technology to physical education teachers, and back to the source, how to promote the ability of future teachers is very important, because physical education teachers and students will step into more challenging teaching scenes in the future. There are more diverse learners nowadays, so teachers should use the technology to improve their teaching effectiveness for the diverse learners (Arslan, 2015; Cengiz, 2015). Physical education teachers learn how to integrate technological knowledge into the teaching and make the TPACK knowledge support the physical education will be more important.
1.2 Teacher Professional Development of PEPT

Teachers’ professional development is a dynamic learning process, which is the development of professional connotation through continuous maintenance of learning and research momentum (Armour, Quennerstedt, Chambers, & Makopoulou, 2017). The process is a long-term, purposeful, uninterrupted, and systematic professional growth activity, in which a series of in-depth reflection and practice are carried out on new affairs and the changing environment. Teaching is a professional field, so teachers need to improve professional knowledge and teaching quality for promoting students' learning effectiveness and meeting their needs (Avalos, 2011).

The professional development of physical education teachers can be carried out in various forms, including empowerment study and related research conferences, so as to promote their professional development (Brent, 2015). As a new PE teacher who will step into the teaching field in the future, he needs to ensure that he has the cognitive view of professional development with the highest standard (Coulter & Woods, 2012).

Therefore, the professional development of physical education teacher education is very important because it will be an opportunity to create a win-win situation. We hope to pay more attention to and cultivate the lifelong professional development of S-PEPT. Although this needs to be accumulated over time, it is a very important conceptual starting point and urges teachers and students to learn how to improve their critical reflection ability (Braga, Jones, Bulger, & Elliott, 2017; Tannehill, Demirhan, Čaplová, & Avsar, 2020).

Therefore, this study will explore which knowledge and viewpoints of S-PEPT will be associated with their TPD, and the main purposes of this study were to:

- What is the validity of the questionnaires for measuring the two constructs?
- Explore the relationships between TPACK and TPD.

2. Method

2.1 Participants

The participants in this study were 305 secondary physical education pre-service teachers from selected universities in Taiwan. There were 207 male and 98 female pre-service teachers. These pre-service teachers included sophomores to masters students.

2.2 Instrument

In this study, two questionnaires, including Technological pedagogical and content knowledge (TPACK) and teacher professional development (TPD) were used. The two questionnaires were filled out at the same time.

The first questionnaire was TPACK. It had four dimensions, includes PCK, TPK, TCK, TPCK. Mainly to understand the teachers’ perceptions of Technology-related Pedagogical Content Knowledge. An example of PCK is as follows, I can encourage students to try to find problems related to the learning of motor skills in PE. An example of TPK is as follows, I can use technology to assist physical education in PE. An example of TCK is as follows, I can use technology to prepare for PE classes, such as mobile phones and tablets. An example of TPCK is as follows, I know how to use technology and equipment to design PE content and teaching strategies.

The second questionnaire was about teacher professional development. It had four dimensions, which include curriculum design and teaching (CDT), class management, and counseling (CMC), research development (RD), and Advanced Study (AS). For an example of CDT, I can use various teaching methods according to the needs of PE class. For an example of CMC, I can properly handle students’ deviations in
PE class. For an example of RD, I am willing to absorb new knowledge in education and innovative teaching. For an example of AS, I am willing to make educational commitments for the future of the students.

2.3 Data Analyses

In this study, the Confirmatory Factor Analysis (CFA) with all of the items and dimensions of the two questionnaires included in one model was performed to clarify the reliability and validity of all of the questionnaires. Moreover, to further understand the relationships among the dimensions of these two questionnaires, correlation analysis and SEM were performed.

3. Results

3.1 Verification of the validity of the two questionnaires

A total of 32 items were retained in the version (i.e. 15 items for TPACK, and 17 items for TPD) as shown in Table 1. It shows the results of the confirmatory factor analysis for the two questionnaires in one model as well as the descriptive statistics for each variable. Each dimension has five questions. The goodness of fit for the CFA of the structure, Chi-square = 789.161, P < .001, degree of freedom = 450, GFI = .86, IFI = .93, TLI = .92, CFI = .93, RMSEA = .050, RMR = .026, Factor loadings = .58-.84, CR = .71-.87, AVE = .45-.60, and Alpha value = .70-.87, was ere obtained, thus confirming the convergent and construct validity of this model for these two questionnaires.

Table 1. The CFA analysis for the TPACK and TPD (N= 305)

<table>
<thead>
<tr>
<th>Construct and measurement items</th>
<th>Factor loadings</th>
<th>t-value</th>
<th>CR</th>
<th>AVE</th>
<th>Alpha value</th>
</tr>
</thead>
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<td></td>
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<td></td>
</tr>
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<td><strong>PCK, mean = 3.98, S.D. = .53</strong></td>
<td>-------</td>
<td>-------</td>
<td>0.71</td>
<td>0.45</td>
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</tr>
<tr>
<td>PCK1</td>
<td>0.66</td>
<td>-------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCK2</td>
<td>0.76</td>
<td>9.28***</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>PCK3</td>
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<td></td>
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<td><strong>TPK, mean = 3.89, S.D. = .64</strong></td>
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<td>-------</td>
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<tr>
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<tr>
<td>TPK4</td>
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<td>13.11***</td>
<td></td>
<td></td>
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<tr>
<td><strong>TCK, mean = 4.19, S.D. = .52</strong></td>
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<td>0.46</td>
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### Construct and measurement items

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<th>CR</th>
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</table>

### Teacher Professional Development

**Curriculum Design and Teaching (CDT)**  
mean = 4.35, S.D. = .48  

<table>
<thead>
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<th>Construct and measurement items</th>
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**Class Management and Counseling (CMC)**  
mean = 4.11, S.D. = .59  

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</table>

**Research Development (RD)**  
mean = 4.42, S.D. = .49  

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<td>RD4</td>
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<tr>
<td>RD5</td>
<td>0.69</td>
<td>11.15***</td>
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</table>

**Advanced Study (AS)**  
mean = 4.46, S.D. = .50  

<table>
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<tbody>
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<td>AS5</td>
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</tbody>
</table>

### 3.2 Correlation between TPACK and TPD

In this study, Pearson’s correlation analysis was used to measure the relationship between TPACK and TPD as shown in Table 2. The correlation analysis results showed that all of the factors of the TPACK Scale were significantly positively correlated with all of the factors of the TPD, as shown in Table 2. To be more specific, PCK was positively correlated with TPD (\( r = .35-43, p < .001 \)). TPK was also positively correlated with TPD (\( r = .22-33, p < .001 \)). TCK was positively correlated with TPD (\( r = .32-44, p < .001 \)), and TPCK was positively correlated with TPD (\( r = .24-42, p < .001 \)).

In addition, CDT was positively correlated with TPACK (\( r = .22-40, p < .001 \)). CMC was positively correlated with TPACK (\( r = .22-40, p < .001 \)). RD was positively correlated with TPACK (\( r = .33-44, p < .001 \)), and AS was also positively correlated with TPACK (\( r = .24-37, p < .001 \)). These findings indicated
that TPACK was highly correlated with TPD. Moreover, the discriminative validity proved that each dimension existed individually and independently.

Table 2. *The correlation between TPACK and TPD*

<table>
<thead>
<tr>
<th></th>
<th>PCK</th>
<th>TPK</th>
<th>TCK</th>
<th>TPCK</th>
<th>CDT</th>
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<th>AS</th>
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<td></td>
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</tr>
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<td>.68</td>
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<td>.33***</td>
<td>.44***</td>
<td>.42***</td>
<td>.77</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMC</td>
<td>.40***</td>
<td>.22***</td>
<td>.32***</td>
<td>.31***</td>
<td>.46***</td>
<td>.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RD</td>
<td>.38***</td>
<td>.33***</td>
<td>.44***</td>
<td>.33***</td>
<td>.62***</td>
<td>.39***</td>
<td>.76</td>
<td></td>
</tr>
<tr>
<td>AS</td>
<td>.35***</td>
<td>.24***</td>
<td>.37***</td>
<td>.24***</td>
<td>.45***</td>
<td>.31***</td>
<td>.59***</td>
<td>.75</td>
</tr>
</tbody>
</table>

*p < .05, **p < .01, ***p < .001

Note 1: The value of the diagonal line is the square root of the average variation extraction (AVE) of the potential variable, and this value should be greater than the value of the off-diagonal line.

3.3 Path analysis

To explore the roles that S-PEPT TPD in their TPACK, this study utilized the path analysis technique to examine the relationships between these variables. The TPACK factors were considered as predictors, while the TPD factors were viewed as a second-order outcome variable. The model was indicated several significant associations between the factors in the TPACK and the second-order TPD (See Figure 1).

In this model, PCK could significantly predict the TPD (β = 0.39, p < .001). The result means that the S-PEPT’s PCK was associated with their development on professional.

In addition, TCK could significantly predict the TPD (β = 0.46, p < .001). The result means using technical knowledge to prepare physical education may predict the future professional development of S-PEPT.
4. Discussion

The PCK and TCK in TPACK can predict TPD, showing that pre-service teachers teach physical education under the construction of basic knowledge, and they can also use the knowledge of technology to prepare courses and teaching materials. This research also showed that S-PEPTs’ perceptions of IT-assisted teaching, therefore should increase the opportunities for IT integration in the teacher education stage to face the diverse students and environment of the 21st century.

In addition, in the face of the impact of the current Covid-19 epidemic on global school education, the application of technology has become the main way to sustain learning, and technology for physical education is the solution that physical education teachers urgently need. The future study is suggested to increase the number of samples, so that the relationships between TPACK and TPD can be clearer and representative. Finally, the further study also can assess the difference of the TPACK and the TPD between in-service and pre-service teachers.

References


Study on the Application of English Essay Correction Network in High School

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Abstract: High school English writing is a difficult point in the cultivation of students' English skills. However, in the domestic senior high school, the assessment feedback is very limited, students rarely make independent corrections. Teachers' guidance and students' practice are not enough, and the level of writing is difficult to be improved. Students' repeated revision of exercises, teachers' timely correction and feedback are an important part of writing, which plays an important role in stimulating students' interest in English writing and improving their writing level. Timely and detailed feedback can help students to improve their English writing. As an important part of writing teaching, feedback plays an increasingly important role. In recent years, different forms of feedback models have been widely used in English writing, and the feedback research has attracted the attention of researchers. Previous studies focused on teachers’ and peer feedback. With the deepening of English teaching reform in high school education in China, the feedback of computer and network has been applied to English writing teaching. The self-developed Pigai System (http://www.pigai.org) is the online intelligent marking network of English composition, which is the product of the development of modern information technology and the construction of education. The research subject of this study is 57 senior 3 students of the third affiliated middle school of Beijing Normal University. This action research is based on Process Approach Theory, Output Hypothesis Zone of Proximal Development Theory with 57 students as the research object, through the arrangement of the use of Pigai System in the two classes, try to answer the following research questions: 1) Can Pigai System stimulate students' interest in English writing? 2) Have the students' writing ability and score been improved after using Pigai System? 3) Can Pigai System enhance students' autonomous learning ability? The study shows that students' learning interest and learning autonomy have been greatly improved.

Key Words: Pigai system, feedback, senior high school English writing teaching, action research

1. Introduction

Automated Essay Scoring (AES) is the use of computer technology to evaluate and score the composition. The study has been for nearly 40 years, and in this process, the latest achievements in statistics, natural language processing and artificial intelligence have been used, and in 1999 it entered the practical application stage (Dikli, 2006). The research and application of automatic composition correction system has become a hot topic in computer assisted foreign language writing teaching at home and abroad. There are more than ten kinds of automatic correction system in foreign countries, including PEG (Project Essay Grade), IEA (Intelligent Essay Assessor) and E-rater. They all have their own characteristics. PEG focuses on language form, IEA focuses on writing content, E - rater pays attention to form and content, but these automatic correction system is mainly used in the writing assessment and writing feedback of students whose mother tongue is English, but not very adapted to Chinese students' English writing.

In this chapter, the author gives a brief introduction to this thesis, including the background information and the importance of carrying out the research.

1.1 The Background Information of Pigai system

At present, the Pigai system, which is widely used in many colleges and universities in China, is a kind of online intelligent correct system. According to the correcting web handbook, the system provides teachers and English learners with online automatic correction service for English compositions in the form of SAAS
(Software-as-a-Service), aiming to provide a writing environment for students, give real-time score and diagnostic feedback, motivate students to revise their compositions and improve writing ability. At the same time, the system helps teachers to understand the students' English writing level more directly and also can reduce the teachers' writing correction workload.

1.2 Significance of the Study

Composition correction and feedback is an important part of English writing teaching, the purpose is to provide writers with information to modify the composition to understand their “organizational logic is not strong" or "content is not rich" or "word errors ". Some of this information is error correction feedback on the surface errors of the learners' composition. Some are feedback on the level of writing discourse. Comments and ratings are also important aspects of information feedback. Research shows that the students' feedback information is the second writing process, which plays an important role in improving students' language ability.

With the development of modern education technology, people have conducted useful teaching experiments and exploration on the use of network platform to improve students' interest in writing, writing methods and writing application ability. However, the study on the use of online writing correction system to strengthen the feedback of English composition is rare.

2. Related Studies

In terms of domestic studies on AES, most researchers attach great importance to reliability and validity of AES. In a 2011 study conducted by Wu & Zhang, questionnaires were distributed to 335 students to investigate their attitudes towards AES in Beijing institute of technology. The results of the questionnaire showed that students would accept scores of AES.

Hu Ke (2016) did a research on writing teaching based on online to offline exploration line (online to offline). The results of the study show that the use of correction network has stimulated most students' interest in writing and improved their writing level, and students generally like to use convenient, timely scoring and timely modification. Most of the students accept the combination of on the line writing mode.

Wang Lianshuang, Wang Liwei (2015), compared the traditional English writing teaching model with the writing teaching mode based on the correction network. The experimental results show that it is helpful for students to improve their English writing ability.

Xiachunlai (2016) uses the assessment of online aided writing evaluation, through system correction, peer evaluation, teacher evaluation, to achieve writing evaluation from a single direction to multi-dimensional. The information technology is integrated into the traditional writing evaluation. The results show that the application of Pigai System to writing multidimensional evaluation contributes to the students' subjective role in the evaluation process, and makes the students change from passive writers to active participants, thus promoting the transformation of teachers' teaching methods and students' learning styles, and realizing the transformation of writing evaluation from results orientation to attention process orientation.

3. Research Design

This chapter focuses on the research design. The research aims to explore whether students in senior high school can enhance their ability of writing, help students improve their consciousness in English learning, and provide some meaningful teaching implications for English writing practice.

3.1 Research Questions

Question one: Can Pigai system stimulate students' interest in English writing?
Question two: Have the students' writing ability and score been improved after using Pigai system? Question three: Can Pigai system enhance students' autonomous learning ability?

3.2 Objective

With the combination of information network technology and language technology in the application of language teaching at home and abroad, the research on information technology and English teaching has gradually increased. Therefore, most of the studies in China are focused on College English teaching. At present, there are few teaching researches on the use of correction network in senior high school students. Since the senior high school students face the entrance examination, the English writing teaching is more urgent and has special practical significance than the college writing teaching. The author hopes that the online feedback mechanism can assist the teacher's single feedback mode, to some extent, can help students improve their consciousness in English learning, and provide some meaningful teaching implications for English writing practice.

3.3 Participants

The participants of this research are two classes in the third grade of the third affiliated middle school of Beijing Normal University. A total of 57 students, of whom the gender ratio is basically the same. The 57 students are ranked in the two classes according to the total score. The students in the science class are at the top 30 of 120, and the liberal arts students are at the top 27 of 60. Although their class English scores are ranked first in grade, their English learning ability and attitude are different. The researcher is the English teacher of both the classes.

3.4 Research Methods & Procedures

The experiment lasts for one school year and regularly arranges writing tasks. Each time the writing task is completed, the students input their writing task into the correction network, which make autonomous error correction. The Pigai system can give students the results of their compositions immediately, and also give the comprehensive comments and the word collocations, low frequency collocation and so on. Students can modify and submit the composition as many times, the platform can give the achievements of previous submissions and save all text records. The basic data of this study is derived from the various records saved by Pigai system, and is assisted by the staff of Pigai company.

In view of the research question, this study adopts the composition sample analysis, Research tools such as questionnaire, interview and so on. The composition sample records the primary version of the data and the final version of the data.

3.5 Research in Application

In order to make the experiment going on smoothly, the author made an action plan. The whole research lasted for 10 months, which can be divided into three stages.

<table>
<thead>
<tr>
<th>month</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planned actions (for students)</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Completion of writing tasks on exercise books</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>
4. Data Analysis and Findings

In the action research, the author relies on Pigai system to arrange writing tasks. After the students finish writing task, the author collects and analyzes the data from all levels to promote the improvement of students’ writing ability. In this chapter, the data and results of the research are described.

4.1 Analyses of Multidimensional Comparison of the First & Final Edition

Table 2
Multidimensional comparison of the First & Final Edition

<table>
<thead>
<tr>
<th></th>
<th>First Edition</th>
<th>Final Edition</th>
<th>The difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lexical richness</td>
<td>5.106667</td>
<td>5.156667</td>
<td>0.05</td>
</tr>
</tbody>
</table>
4.2 Analysis of Frequency of the Major Mistakes per thousand copies in the First-Edition & the Final Edition

Table 3
The comparison of Frequency of the Major Mistakes per thousand copies in the First& Final-Edition

<table>
<thead>
<tr>
<th></th>
<th>First Edition</th>
<th>Final Edition</th>
<th>The difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>sentence</td>
<td>185.88</td>
<td>78.93</td>
<td>106.95</td>
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<tr>
<td>spelling</td>
<td>1055.86</td>
<td>702.26</td>
<td>353.6</td>
</tr>
<tr>
<td>collocation</td>
<td>101.45</td>
<td>43.26</td>
<td>58.19</td>
</tr>
<tr>
<td>vocabulary</td>
<td>87.55</td>
<td>40.99</td>
<td>46.56</td>
</tr>
<tr>
<td>part - of - speech misuse</td>
<td>21.22</td>
<td>11.53</td>
<td>9.69</td>
</tr>
</tbody>
</table>

4.3 Analysis of the comparison of four test results in Haidian district

Table 4
The comparison of four test results in Haidian district

<table>
<thead>
<tr>
<th>Examination</th>
<th>midterm</th>
<th>End of term</th>
<th>The First mock examination</th>
<th>The second mock examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total score</td>
<td>35</td>
<td>35</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>Average of Haidian district</td>
<td>21.35</td>
<td>21.43</td>
<td>23.89</td>
<td>24.46</td>
</tr>
</tbody>
</table>
5. Conclusion

This study did a research into the application of English essay correction network in high school by analyzing related domestic and foreign research and adopting the methods of questionnaires, interviews, tests and observations. All the researches in this study are based on the high school English writing teaching in Class One and Class Five in the third grade of the third affiliated middle school of Beijing Normal University. The results show that the application of English essay correction network in high school is necessary, feasible and effective.

5.1 Major Findings

This part mainly explains some findings from the following aspects: changes of the teaching concept and the role of teachers, changes of writing purposes, and limitations and suggestions for future research.

5.1.1 Changes of the Teaching Concept and the Role of Teachers

The application of Pigai system makes learning a kind of self-organizing behavior of students, students are the center of learning activities and the main body of teaching process, and teachers are more to provide guidance, support and service for learners. With the rapid development of network technology, network resources are available, students can obtain and use the learning resources no less than teachers. At this time, the main role of teachers is no longer the transfer of knowledge resources, but should be the integration of autonomous learning resources. Teachers' responsibility is to take "students as the center" of educational philosophy, integrate the excellent learning resources on the network, make full use of diversified resources and teaching means, stimulate students to constantly think, cultivate students' interest in writing, guide students to learn autonomously, and give students the necessary learning support and evaluation feedback in a timely manner. In terms of English writing teaching, teachers should integrate writing learning resources, mining students' writing data, design the precise teaching of data driven, and evaluate students' writing level from a professional perspective.

5.1.2 Changes of Writing Purposes

In traditional writing teaching, students “writing for writing” cannot be dull, because students lack interest, they will not take seriously. The essence of language is application; the essence of writing is the expression of thought and emotion (Wang Haixiao, 2014). If students write in order to practice and ignore the expressive function of writing, it may cause students to pay too much attention to grammar, vocabulary, structure and other forms of problems and ignore the most core part of the article, which is, content and thought. Network technology based on big data can help solve the problem of writing goal from two aspects. On the one hand, writing software and online writing system can correct most of the mistakes in the form, so that students have more time to think about the content of the article. On the other hand, an open network platform makes every writing a "sharing". Such as teachers can let students write emails to
others, or share reviews or comments on the internet, or use the way of students' mutual evaluation, so that
each writing has " readers ", so that each student is not only the author, but also the reader. Thus, writing is
no longer a dull exercise, but the true information and emotional transmission, and return to the most
authentic purpose of writing.

5.2 Limitations and Suggestions for Future Research

Through this action research, the application of Pigai system in senior high school English writing teaching
has positive significance to improve students' autonomous English writing ability, stimulate students'
learning motivation and improve students' self - efficacy.

In the actual use and semi - open interview, this study also found some shortcomings of the
correction network, such as the content to the topic, the text structure, logic and so on cannot be
comprehensively assessed; The system cannot recognize the more complex sentences; "low frequency
warning" is suspected Chinglish, but it fails to give the reference usage; The comments are generally strong
and not evaluated in detail.

In view of this, this study puts forward the following suggestions: first, the correction network
should enrich its corpus, increase the suggestions, and improve its computer intelligent analysis, logic
analysis and other technologies; Second, it is beneficial to break the boundary between teachers and
students, break the boundary between students, achieve equal and sincere writing communication, improve
students' cooperative learning ability and cultivate their teamwork ability and innovative spirit. Third,
teachers should not rely solely on the Pigai system, but should make full use of the advantages of the
correction network, using the teachers' comments of the nets to comment on the students' composition in
time and comment on the common weaknesses. Only when the online instant feedback, peer feedback and
teacher feedback are combined in middle school English writing teaching, students' autonomous writing
ability and writing teaching quality will be improved.

Of course, this study is still to be improved. First of all, the subjects of this study are those of the
third grade of our school, and cannot represent the other students. The research institute students to
participate in the college entrance examination, most of the students have a more urgent need to improve
writing ability, so the general effectiveness of the research results to be further demonstrated in the follow-
up study. Secondly, the study time is short, and lack of control group,

It may limit the scientific and objective evaluation of the cool network. But it is worth affirming
that the teaching mode of English autonomous writing based on Pigai System the deficiency of traditional
writing teaching to some extent, which is conducive to the improvement of the teaching quality of senior
high school English writing.

Acknowledgements

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We Learn from Each Other: Informal Learning in a Facebook Community of Older Adults

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Abstract: Older adults represent a growing population of users participating in Facebook communities. Sharing and posting in these platforms exhibit information exchanges that can be considered as informal learning in social media. Although research uncovered rich details of informal learning of older adults in online communities, studies based on social media communities remain a research frontier. In using a netnographic approach, we add to the limited literature and collected social media data from thirty-one (31) members of a Facebook community of older adults. A total of 1076 posts and 631 comments were collected. We applied thematic analysis using the social exchange theory as our theoretical foundation and found three salient themes in the analysis of information exchanges namely (1) Keeping healthy, (2) Ensuring safety, and (3) Family relationships. We present the current state of research in the use of online communities of older adults to support informal learning, discuss our methodology, state our findings, and highlight the implications of this study.

Keywords: Older adults, online communities, information exchanges, informal learning, netnography, social media, Facebook communities

1. Introduction

Population ageing coupled with wider Internet access ushered in a new generation of older adults who are heavily invested in social media platforms such as Facebook. In the last five years, older adults represent the highest increase in Internet usage across all age groups and social media participation is one of their major activities online (Ivan, 2019; Yu, 2020). Primarily designed as a social technology, Facebook has become a tool where information can be shared and acquired in what research referred to as information exchanges (Carvalho & Lopes, 2016; Costello, McDermott, & Wallace, 2017). Within the wide spectrum of Facebook arena of tools is the Facebook Community, a platform where users can interact and therefore exchange information (Johnson, Lawson, & Ames, 2018). For older adults, cognitive decline remains to be one of their generation’s constant struggle and online communities can provide a venue to deter this dilemma. Past studies support the value of online communities as a platform that encourage information exchanges among older adults.

Late life can be viewed as a phase where older adults have gained rich life experiences and professional expertise that are rarely captured. The emergence of older adults in Facebook communities is an opportunity where this information can be archived, acquired, and studied to depict the information sharing and seeking behaviors of older adults online. In these online communities, older adults discuss freely their opinions, share and seek information, and participate in social interactions that are all important facets of what constitutes a community (Chang, Chang, Lian, & Wang, 2018; Yu, Ellison, & Lampe, 2018). Discussions online is a tacit process which is difficult to observe but its naturalistic data affords research to investigate these information exchanges to provide a clearer picture of the cognitive behavior of older adults (Ivan, 2019).

In this study, we analyzed posts and comments from select members of a Facebook community of older adults to find themes within their online discourses. Using netnography and social exchange theory, we contribute to present research in several fronts. First, studying the themes and topics within online

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communities generated by the users themselves will provide a deeper understanding of what information exchanges occur in the digital space from the perspective of older adults (Kapoor et al., 2018). Second, a qualitative inquiry into the online discourses of Filipino older adults in a Facebook community will add to the limited research diversity in the use of technology for informal learning in adult education (Bora Jin, Kim, & Baumgartner, 2019). Third, most research included participants in Western countries even when social media is gaining popularity in developing economies (Yu, 2020). Fourth, we contribute to limited applicability of the social exchange theory by operationalizing its constructs and applying it to information exchanges occurring online (Cooper-Thomas & Morrison, 2018). Lastly, we present online communities as an information exchange community where informal learning takes place when most research established these platforms as a place where older adults spend leisure time and socially interact. We discuss related studies and the theoretical underpinnings in the next section followed by our methodology and discussion of results. Recognizing the limitations of our study, we highlight opportunities to guide future research endeavors.

2. Related Studies and Social Exchange Theory

Participation in information exchanges by older adults in online communities is driven primarily by factors associated in late life. Physical and psychological deterioration translates to lesser social activities and online communities are venues where older adults interact with others. A prominent topic of research in online communities and older adults looked at how online communities provide social support (Wannatrong, Yoannok, & Srisuk, 2018; Willard, Cremers, Man, Van Rossum, et al., 2018) and social connectedness (Anderson, 2019; Burmeister, 2012). Assisting others and sharing experiences, knowledge, and opinions with like-minded peers related to ageing appears to enhance the feeling of social support and social connectedness (Burmeister, 2012; Litchman, Rothwell, & Edelman, 2017; Willard, Cremers, Man, Van Rossum, et al., 2018).

Retirement signals a transition in late life where older adults spend more time on the Internet for leisure and learning. Prior literature investigated discussion forums catering to older adults such as Greypath in Australia (Coelho & Duarte, 2016), Oldkids and LaoYouBang in China (Pan, 2017; Zhao, Zhang, & Ma, 2020), and numerous English-based discussion forums (Nimrod, 2013; Nimrod & Berdychevsky, 2018). Various topics are discussed in these platforms, proof that older adults engage in informal learning online. Professional knowledge gained across lifespan is shared as well such that older adults are considered as important contributors in an online community (Kowalik & Nielek, 2016).

While research on Internet-based online communities is flourishing, studies on online communities found in social media is scant despite recent change of preference among older adults (Beringer et al., 2017; Blieszner, Ogletree, & Adams, 2019). However, older adults’ participation in online communities have recently spurred scholarly curiosity. Facebook communities that cater primarily to information exchanges among older adults are in health-related topics include diabetes (Litchman, Rothwell, & Edelman, 2018) and disability (Baker, Bricout, Moon, Coughlan, & Pater, 2013). Discussions focused on sharing of experiences, coping strategies, and self-interventions to challenges associated with ageing.

The social exchange theory of Homans (1958) views human behaviors as a direct result of social negotiations among individuals. In the exchange process, social interactions among individuals are based on the assessment of the costs and benefits. Online communities are virtual gatherings of individuals who participate in various forms of symbolic social exchanges. Contrary to economic social exchanges, interactions within these communities exhibit forms of symbolic social exchanges where intangible goods such as emotional support, enjoyment, information, and opinions are traded, forming new relationships among its members (Byoungho Jin, Park, & Kim, 2010; Jung, 2018; Tsai & Kang, 2019). In the study of Jung (2018), members posting online information such as personal life experiences represent self-expression and the comments or reactions from the other members are interaction cues that support social exchange in the virtual environment. The quantitative study of Yan, Wang, Chen and Zhang (2016) tested this theory in the context of online health communities by operationalizing costs and benefits in their
investigation revealing that personal benefits such as self-worth, reputation, and support encourages participation.

3. Methodology

Research in computer mediated communication calls for novel methodological approaches to understand the digital content within these social media platforms. Netnography has been found to be an appropriate tool to depict the culture of a specific social cluster present in online communities. Research using this method uncovered rich insights into the information exchanges among older adults (Ivan, 2019; Kowalik & Nielek, 2016; Zhao et al., 2020).

3.1 An Ethical Approach to Netnography

The convenience of collecting naturalistic data emerging from the daily occupancy of users along with the potential of harm and privacy risks necessitates ethical considerations (Kantanen & Manninen, 2016). The practice of digital research methods to investigate online communities is arguably well founded in recent literatures but approaches are varied and largely motivated by research settings such as the platform, the participants, and the study objectives (Germain, Harris, Mackay, & Maxwell, 2018; Mkono & Tribe, 2017). The ambiguity between what constitutes the public and private domains is at the fulcrum of existing debates among scholars who practice digital research methods (Heinonen & Medberg, 2018; Lawless, Augoustinos, & LeCouteur, 2018). Most online communities require membership, governed by a set of rules and activities are influenced by the technology platform. These elements evolve as communities grow and these online social gatherings adapt to technological improvements of platforms (Fielding et al., 2016; Kozinets, 2013).

Upon approval of the university ethics board of the project’s methodology, we commenced data collection by approaching thirty-one (31) older adults who are members of a Facebook community using a snowballing technique in the recruitment process. An informed consent was explained to participants and approval was given prior to the formal collection of data. Posts from the participants were collected. Comments were filtered out to include only participants who provided their consent. Lastly, an approval from one of the community managers was given to the primary researcher prior to the collection of data.

3.2 Site: A Facebook Community of Older Adults

A Facebook community comprising of 71,133 Filipino older adults based in the Philippines was selected based on the number of members and frequency of posts. As required by netnography, the first author immersed in the community on March of 2019 to address the requirement of prolonged embeddedness with the community being studied. While communities of older adults may exist in other platforms, the choice of Facebook is motivated by its popularity among Filipinos and older adults worldwide (Catedrilla, 2017; Sanchez, 2020; Yu, 2020).

3.3 Thematic Analysis on Social Media Posts and Comments

A total of 1,707 posts and comments were collected from February to June of 2020 during the data collection phase. The Facebook community posts and comments from the selected participants covered the first post or comment of the participants until their last contribution to the platform until the end of May of 2020. These posts and comments represent bi-directional exchanges of community members’ thoughts, emotions, and beliefs (Sutikno, Handayani, Stiawan, Riyadi, & Subroto, 2016). These exchanges were organized into a data set according to participant, type (post or comment), date, and type of content (image, picture, gif, or emoji). Each post or comment is assigned a unique identification number for traceability.
Excerpts, or portions of the posts and comments were selected using Dedoose, a qualitative data analysis software (Batsis et al., 2018; Taylor, Bogdan, & DeVault, 2016). A codebook was developed based on prior and similar literatures in the application of netnography in the participation of older adults in online communities (Balcerzak & Nielek, 2017; Haris, Majid, Abdullah, & Osman, 2015; Harley, Howland, Harris, & Redlich, 2015). The content of the codebook followed the format of Roberts, Dowell, and Nie (2019) and included the name of the code, its definition, criteria for inclusion, and sample post or comment. This codebook was constantly updated, and data was iteratively analyzed by the first author and the second author when an excerpt demonstrates a new code. Five versions of the codebook representing four iterations of analyses were conducted. Disagreements in the application of code were discussed in 19 sessions using Zoom and written in memos. This resulted to constant reflections from the two authors in the analysis of the data set. Meetings were recorded and transcribed. Agreements and disagreements were noted resulting to an acceptable threshold of Inter Rater Reliability or IRR of 91.59% (Graham, Milanowski, & Miller, 2012).

Themes are defined as patterns of codes that can be grouped together based on similarities and contradictions (Braun & Clarke, 2006). We analyzed codes from within and across the posts and comments of the participants and checked against our codebook to search for learning related clusters of codes to define our themes (Barbosa Neves, Franz, Judges, Beermann, & Baecker, 2019). In addition, we looked at these themes as frequently occurring codes in posts or comments. We extracted this data from Dedoose using its code co-occurrence feature to support our primary themes from the data (Talanquer, 2014; Taylor et al., 2016). The final set of themes, their corresponding codes and names were finalized by Coder A and Coder B.

4. Results

Based on the analysis of data, there are three themes in the information exchanges of older adults in this specific Facebook community:

4.1 Keeping Healthy

The most salient theme from the analysis of our data revolves around discussions about health and the general well-being of older adults. There are 22 participants who shared their daily activities on how they keep healthy such as their daily exercise routines, diet, and vitamins intake to address health challenges in late life. Community members respond to these posts by sharing comments and images of their daily activities. For example, three participants (004, 005, 007) shared their current health crisis with the group which solicited advices from other members ranging from prior experiences from a sickness and how they were able to cope up with that challenge. Physical activities were frequently shared by members and usually posted with images of them walking, running, and dancing Zumba. A male participant (021), is a runner who posts pictures of him during fun runs, his medals, and provides advice to the community on how this physical activity keeps him fit and healthy. A female participant (004), shares images of her while dancing Zumba with friends and relate this activity to her health and well-being. Past studies reveal that information exchanges on health and well-being is popular among older adults participating in online communities (Litchman et al., 2017, 2018). Knowledge shared and gained in these platforms provide meaning and support as older adults grapple with the challenges of late life through constant informal learning interactions with others (Bora Jin et al., 2019).

4.2 Ensuring Safety

Frailty is common in late life and older adults are curious how others deal with this challenge. Discussions about safety were mentioned by 16 participants and were shared through text-based posts and to a lesser extent, image-based content. Natural disasters are frequent in the Philippines, and older adults appear to be
severely affected by these situations. During typhoons and volcanic eruptions, participants remind other members to stay indoors to keep safe. In several posts (003, 005, 008, 28), members will share current information about rains and floods and how it endangers the lives of older adults. During the COVID-19 lockdown, members (003, 005, 017, 029) posted government reminders for older adults to stay indoors that encouraged other members to comment their opinions and inquiries resulting to active discussions about safety. Addressing safety concerns discussed in social media can encourage autonomy and independence while acknowledging limitations in late life (Haris et al., 2015). Online informal learning on safety can complement healthcare professionals in ensuring that older adults live well (Miguel & Da Luz, 2017).

4.3 Family Relationships

In late life, family relationships become as important as health and safety. Issues with family relationships were discussed freely by 14 members with the rest of the community. A male member (007), shares arguments with his children regarding living arrangements and financial support. Advises and inspirational messages from other members are given in the form of comments. Community members value family relationships and this is usually expressed in a form of inspirational quotations shared by some of the participants exhibiting forms of social support (003, 029,030). Two female members (028, 030) narrates their stories through posts on how they care for their adult children and siblings with special needs and how it provides meaning in their lives. Notable among these Facebook posts are daily activities, selfies, and images of family members and grandchildren. During the COVID-19 lockdown, some members were separated from their family members and posted pictures on how they maintain relationships through technology. Similar studies find that older adults participate more in discussions regarding family relationships and are primarily driven by the joy of sharing happy memories with other members (Nimrod, 2013; Zhao et al., 2020).

5. Conclusion

In summary, this study used netnography to identify key themes in the information exchanges of older adults in a Facebook community. We found three prominent themes in these discussions: keeping healthy, ensuring safety, and family relationships. We adopted a qualitative inquiry into naturally occurring social media data to identify salient points of conversations within a Facebook community of older adults. Population ageing remains to be a global issue that can be addressed by scholars from various disciplines such as technology, social, and health sciences (Zhao et al., 2020). Initial findings indicate that informal learning takes place in Facebook communities among members where they learn from each other in what is referred to as online personal learning networks (Morrison, 2015; Morrison & McCutheon, 2019). The desire to engage in informal learning activities through these networks supports a recent revelation in literature that older adults can learn, participate, and relate better in a like-minded community (Morrison & McCutheon, 2019).

The exploratory nature and sample size of this study does not equate to confirmatory findings but establish clear research pathways and practical recommendations. First, cognizant of prior works on the use of social media for active ageing (Chan & Suarez, 2017; Daniel, 2018), future research can investigate how online social interactions in these platforms improve the general well-being of older adults. Second, as an everyday social technology, Facebook is a cost-effective vehicle in promoting advocacies related to active ageing given that informal learning takes place within these platforms (Bora Jin et al., 2019; Quinn, 2019). Third, information dissemination is fast in online communities, appropriate verification mechanisms should be established to deter misinformation especially in content related to health and safety (Carvalho & Lopes, 2016). Fourth, from the academic perspective, informal learning is a naturally occurring process in Facebook communities and it is imperative for stakeholders in education to find ways on how to capitalize on this opportunity for lifelong learning especially for older adults suffering from cognitive decline (Lawless et al., 2018). Lastly, from a methodological standpoint, we
utilized a purely netnographic approach in this study and future studies of online communities may want to combine traditional methods such as interviews to capture a holistic view of why informal learning encourages participation from older adults (Fenton & Procter, 2019).

Acknowledgments

The authors acknowledge the invaluable inputs, participation, and cooperation of the Facebook community and its members who served as the test cases of this research. The authors also thank their affiliated institutions, Jose Rizal University and De La Salle University - Manila, for their unwavering support and assistance in completing this endeavor. Lastly, the authors extend their appreciation to the reviewers whose insights, opinions, and advices assisted in making this undertaking better.

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The Development of High School Students ICT-related Competencies by Redesigning the Science and Technology Innovation Courses: A Case of a Mainland Chinese High School

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Abstract: The purpose of the current study is to explore the development of high school students’ ICT-related competencies by redesigning a compulsory course for science and technology innovation. Results showed that the course has been implemented successfully. And the teachers teaching behaviors, students learning style, the classroom communication atmosphere, and the after-class evaluation have been positively changed.

Keywords: High school students, ICT-related competencies, science and technology innovation

1. Introduction

The Ministry of Education (MOE) of China released the Education Informatization 2.0 Action Plan on 13th April, 2018. In accordance with this document, the following development goals should be achieved by 2020 in China: The teaching applications should cover all teachers, the learning applications should cover all school-aged students and digital campus construction should cover all schools. The ICT-related competencies and information literacy of teachers and students should be highly developed, and the "Internet + education" platform should be established. The Education Informationization 2.0 Action Plan is an internal developmental requirement to realize new leap-forward based on historical and current achievements. It is an inevitable choice to adapt to the development of education in nowadays intelligent environment. It is also a key measure to fully stimulate the revolutionary impacts of information technologies, and an effective way to accelerate the modernization of education.

Traditional high school education pays too much attention to the results of college entrance examination, lays emphasis on knowledge transmission (Brooks, Normore, & Wilkinson, 2017), emphasizes too much on exam-oriented and exam-selected educational functions and curriculum management (Lim, & Khine, 2006). In high schools, the exam-oriented pressure brought by the college entrance examination forces teachers and students to blindly pursue the enrollment rate, and ignore the personalized development of students and the characteristic of schools (Zhou, Zhang, & Li, 2011). Consequently, the single and rigid school development strategies restrict students’ creativity and imagination, students’ independent exploration and cooperative learning. The characteristics of high schools are not obvious and the "exam-oriented education" is misunderstood (Wang & Shi, 2004). Therefore, in response to the educational problems brought about by this ICT-enabled era, it is vital for high schools to develop new ways to handle the relationship between students’ comprehensive quality training and college entrance examination results, and further to promote the diversification of high school education (Chen & Xu, 2014).
2. Background of the Case Study

This study is located in the High School Affiliated to Guangxi Normal University (HSAGXNU), which is one of the top 10 key and exemplary high schools in Guangxi province, south-west China. In order to develop students’ ICT-related competencies, the HSAGXNU started with the science and technology innovation curriculum construction, and research projects on the science and technology innovation curriculum integration practices in 2011. Meanwhile, the HSAGXNU focused on the development of the science and technology innovation core courses and established a comprehensive curriculum development framework, which included four major perspectives: administration, school culture, curriculum and activities (see figure 1). The core idea of the science and technology innovation education was project-based teaching. It should fully understand students’ learning interests, integrate digital tools, advocate creation and sharing, cultivate students’ interdisciplinary problem-solving ability and teamwork spirits. The effective integration of the science and technology innovation education and ICT should make full use of the advantages of resource database and serve for the teaching and learning (Zhu, 2011).

![Figure 1. The Comprehensive Curriculum Development Framework for Developing Students’ ICT-related Competencies in HSAGXNU.](image)

3. Participants

In 2014, the HSAGXNU established the overall goal----"to establish a scientific curriculum system, stimulate every student's innovation potential". Meanwhile the HSAGXNU also developed the curriculum integration mode----"science and technology innovation talent training strategies", to educate the innovative quality of outstanding talents. Since the summer of 2014, the HSAGXNU has integrated information technology courses, comprehensive practice courses and general courses into science and technology innovation courses, teaching 3 class hours per week. During the following three years, totally 49 teachers and 1670 students have participated in these courses. The teaching team was selected from different specialization, English, Physics, Mathematics, ICT, Chemistry, Science, and Engineering. And all the participants were higher school students from Grade one and two, aged from 15-17 years old. Each student has received a total of 160 class hours of science and technology innovation training. In the spring of 2020, these courses have been taught to 1798 students, and 54 teachers have involved in these courses. The HSAGXNU invited five experts from the faculty of education, Guangxi Normal University (GXNU) to work with the teaching team to design the course contents. After five consultation meetings, the course contents were determined as shown in the following table 1. These courses have almost realized the transformation from the "elite students' innovation ability training" into "innovation literacy training for all students". The implementation of the science and technology innovation compulsory courses has ensured
sufficient time to develop students’ scientific and technological innovation ability and ICT-related competencies in the high school.

Table 1. The contents of the science and technology innovation courses in HSAGXNU

<table>
<thead>
<tr>
<th>Course No.</th>
<th>Contents</th>
<th>Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Creative electronic musical instrument based on Arduino</td>
<td>ICT-related Competencies</td>
</tr>
<tr>
<td>2</td>
<td>Design and manufacture of intelligent small lamp based on Arduino</td>
<td>ICT-related Competencies</td>
</tr>
<tr>
<td>3</td>
<td>3D Printing Course</td>
<td>Technological Design</td>
</tr>
<tr>
<td>4</td>
<td>Simple motor design and manufacture</td>
<td>Inquiry-based Instruction</td>
</tr>
<tr>
<td>5</td>
<td>The exploration of drinking birds</td>
<td>Inquiry-based Instruction</td>
</tr>
<tr>
<td>6</td>
<td>Design and manufacture of wire gyro</td>
<td>Inquiry-based Instruction</td>
</tr>
<tr>
<td>7</td>
<td>Design and manufacture of falling body</td>
<td>Inquiry-based Instruction</td>
</tr>
</tbody>
</table>

4. Results

4.1 Teaching and Learning Achievements

4.1.1 Teachers

Teachers’ enthusiasm on teaching and research has been greatly encouraged. Teachers have won a series of awards for science and technology (See table 2). For instance, two research projects won the first prize in Guangxi Provincial Based Education Achievement Competitions in 2018. Mr. Yu-Hua LI was rated as “the National Top 10 Science and Technology Counselors in China” by Chinese Association for Science and Technology. Mr. Yu-Qiao Ma and Mr. Rui-Hua Mao have won several national and provincial level awards and outstanding science and technology instructors.

Table 2. Teachers’ Science and Technology Competition Awards in HSAGXNU

<table>
<thead>
<tr>
<th>Category</th>
<th>National level</th>
<th>Provincial level</th>
<th>Municipal level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td>4</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

4.1.2 Students

Through the implementation of the science and technology innovation courses and the in-depth promotion of project-based teaching, the HSAGXNU students’ innovation consciousness and competencies have been significantly enhanced, and their scientific and technological literacy has been generally improved. From 2014 to 2019, the HSAGXNU students have won more than 20 national invention patents and hundreds of national and provincial science and technology competition prizes (See table 3).

Table 3. Students’ Science and Technology Competition Awards in HSAGXNU

<table>
<thead>
<tr>
<th>Category</th>
<th>National level</th>
<th>Provincial level</th>
<th>Municipal level</th>
<th>Student Patents</th>
<th>Students’ Invention and Creation Achievement Awards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td>16</td>
<td>90</td>
<td>120</td>
<td>8</td>
<td>11</td>
</tr>
</tbody>
</table>
4.2 Feedback and Reflection from Teachers

Teacher A: With strong interests in science and technology innovation, my students have carried out continuous innovation and production through project-based learning, participated in series of competitions, presented their scientific and technological literacy and gained great growth and harvest, which made me more determined on the development path of science and technology innovation.

Teacher B: Through project-based teaching, STEAM education has been carried out in a real way in the classroom. My students actively participated and explored in classroom activities. They began to question, to challenge, and place more emphasis on practice.

Teacher C: On the way of science and technology innovation education, there are many surprises and gains. My graduates of previous years had highly approved the scientific foundation of what they had learned in our high school and found their own future career interests.

5. Discussion and Conclusion

Considering the educational context in China, this study was conducted to provide a basis for holistic understanding of developing high school students' ICT-related competencies by redesigning the science and technology innovation curriculum. The HSAGXNU have made a bold attempt to integrate ICT and curriculum in the process of educational information technology reform, and made careful arrangements and systematic plans in terms of school organization, educational theory, culture and evaluation and so on. The contribution of the study is discussed the sustained changes with respect to the following perspectives.

Teachers' teaching behaviors and students' learning style have been changed. The teachers' teaching behaviors have been changed. They returned the class to the students, and the students learning style has changed from passive to active. They could have learning space for independent thinking, and carry out group cooperation to achieve learning effects.

The classroom communication atmosphere has been changed. The reform of educational information technology has brought students a platform to show themselves, and students have more opportunities to participate in classroom instructional discussions. The classroom has been changed from lecture to discussion or cooperative learning in a harmonious atmosphere.

The after-class evaluation has been changed. In the science and technology innovation curriculum, the evaluation method was no longer the single evaluation method based on academic achievement, instead, it had established the evaluation system through teaching and learning process and credit system, and evaluated students' learning outcomes from more scientific, objective and comprehensive perspectives.

The development of high school students' ICT-related competencies is a systematical project and an important symbol of modernization of education. Therefore, it requires principals, teachers, educational administrators and researchers to collaboratively make efforts in terms of school organization, teaching process, teaching modes, teaching quality, and evaluation.

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Comparing effects of brain training and role-playing games on problem-solving speed

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Abstract: Problem-solving skills are increasingly becoming a desired skill in the workplace today. Although formal education will be the best way to develop one’s own problem-solving skills, the problems addressed are often clearly defined and structured. However, problems in the real world are often ill-structured and requires complex problem-solving. Many researches indicate that video games can be an alternative to developing problem-solving skills given that the problem and environment are ill-structured. Based on prior comparative findings on strategy-fast-paced video games and role-playing-brain training games, this study investigates whether participants will evidence greater learning gains in problem-solving speed within a sandwich Tower of Hanoi-a fast-paced-brain-training or a strategy role-playing video game-Tower of Hanoi methodology. There is closer similarity between the fast-paced video game to the Tower of Hanoi. Hence, we hypothesize that this closer similarity may result in improved problem-solving speed since the development of rules may be analogically similar. In our study, findings indicate that participants who play Idle Supermarket Tycoon (strategy role-playing video game) evidence more pre-post-test learning gains (problem-solving speed) compared to Mario Kart Tour (fast-paced-brain-training video game). This finding confirms prior research that strategy and role-playing video games are more effective than fast-paced and brain training games in developing problem-solving skills. It also hints that increased cognitive load due to multivariate complexity may be traded off by motivation to form or activate rules when the problem is personally relevant or simulates real-life challenges. However, there are several limitations to the experiment in terms of specificity due to the small sample size. This is due to the research being carried out during the country’s COVID-19 movement control order/lockdown and the need for more data to be conclusive. Nevertheless, we hope it can serve as a catalyst for more research and studies in the field.

Keywords: Problem-solving, analogical transfer, fast-paced video game, strategy video game, role-playing video game, brain training video game, Tower of Hanoi

1. Introduction

Problem-solving has become essential to school, career, and life in general (Bransford & Stein, 1984; Jonassen, 1997). However, formal education will usually provide assessment situations which are often clearly-defined and structured while the problems found in the real world are often ill-structured and require complex problem-solving skills (Shute, Wang, Greiff, Zhao & Moore, 2016). Hence, informal education has great potential and have flourished in many countries.

One form of informal education is video games. Video games encourage strategy and goal development (Gee, 2005). With this in mind, video games can be seen as an alternative in developing problem-solving skills among people. Some studies, which aim to examine the link between video games and problem-solving skills development indicate the following:

a) sustained playing of strategy games improves the problem-solving skills of students which in turn increases their academic grades more than fast-paced games (Adachi & Willoughby, 2013).
b) participants who play World of Warcraft, a roleplaying video game, obtain better results for both the Tower of Hanoi and the PISA problem-solving post-tests compared to those who play CogniFit, a brain training video game (Emihovich, 2017).

These findings are interesting as they compare the efficacy of playing strategy vs. fast-paced video games, brain training vs. roleplaying video games and reveal that multivariate games which relate to
1.1. Objective

Analogical model-based transfers such as by Goel and Craw (2005) are fundamental to the Learning Sciences. Many studies have revealed positive effects towards problem-solving skills, arising from playing video games. Due to differences in culture (Canada, US and Malaysia), we aim to:

a) reconfirm Emihovich’s (2017) findings;
b) investigate whether the closer similarity between the fast-paced video game *Mario Kart Tour* to the *Tower of Hanoi* would result in improved problem-solving speed since the development of rules may be analogically similar.

If the findings are positive, then strategy and role-playing video games should be given more attention interspersed with speed and brain training games in developing problem-solving skills. In the following section, we review related work.

2. Related work

4.1 Aggregated assessment of problem-solving skills

To assess problem-solving holistically, Shute, Wang, Greiff, Zhao and Moore (2016) ask participants to play a video game *Use Your Brainz* for three hours across three consecutive days. *Use Your Brainz* is a modified version of the video game *Plant vs. Zombies 2* created by *Popcap Games* and its publisher *Electronic Arts*. On the fourth day, two tests are carried out, i.e., *Raven’s Progressive Matrices* (to measure reasoning and simple problem-solving skills) and *MicroDYN* (to measure complex problem-solving skills).

The participants in the study are 55 7th grade students at a middle school located in suburban Illinois. Data is collected using stealth assessment, similar to an audit trail. A competency model (Figure 1) divides problem-solving into four facets, i.e., “analyzing givens and constraints,” “planning a solution pathway,” “using tools and resources effectively and efficiently” and “monitoring and evaluating progress.” Data such as “players plant iceberg lettuce within the range of a snapdragon attack is not ideal as planting both iceberg and snapdragon near each other will negate each other’s effect” will be mapped to the four facets in the competency model. This in turn will contribute to the overall score.

Hence, the competency model not only provides a more well-defined assessment of problem-solving skills but also provides a means to focus on a player’s stronger or weaker aspects.
With these four facets of problem-solving skills in mind, we next look into another two comparative studies, i.e. the efficacy of strategy game vs. fast-paced game and the efficacy of brain-training video game vs. roleplaying video game.

2.1 Strategy game vs. fast-paced game

Adachi and Willoughby (2013) hypothesize that if video games can increase students’ problem-solving skills, they can also positively improve students’ academic grades. As such, they investigate the efficacy of strategy video games in contrast with fast-paced video games. With regards to strategy video games, Adachi and Willoughby hypothesize that sustained playing can improve problem-solving skills. This is because strategy games encourage players to gather and collect information first and then proceed to use that information to think of strategies to the problem.

For example, for the video game Splinter Cell, players take control of the role of a black-ops agent and must use stealth and remain undetected from the eyes of the enemies in the game. As such, players are encouraged to study the scene in the game, the behavior of the enemies and formulate a plan or strategy of attack. In contrast, fast-paced video games require players to take immediate action. This leaves very little time for players to gather information and formulate strategies in solving the problem. Hence, Adachi and Willoughby hypothesize that sustained playing of fast-paced video games will not be able to increase players’ problem-solving skills.

They send out surveys to students from eight different high schools in an Ontario, Canada school district. Students in grades 9, 10, 11 and 12 are tracked as they progress through different grades. Questions include gender, the number of computers they have at their homes, parents’ education level, whether students have had prior experience in playing strategic and fast-paced video games, the frequency of their playtime, how much they thought of strategies in the game and the academic grades they obtain through the years. Findings indicate that sustained playing of strategy games do increase the problem-solving skills of the students and academic grades. However, this does not apply to fast-paced games.

2.2 Brain-training video game vs. roleplaying video game

Emihovich’s (2017) comparative study on the effects of brain training video game and roleplaying video game on problem-solving skills sheds more light on how we can develop problem-solving skills. He hypothesizes that brain training video games will be able to improve rule application in problem-solving better than a roleplaying video game. This is because brain-training video games enable players to
repeatedly apply explicit rules to solve problems. On the contrary, roleplaying video games will be able to promote the transfer of problem-solving skills better than brain-training video games because the former requires players to address authentic ill-structured problems in a richly detailed immersive environment.

Rule application requires the problem-solver to constantly reify the representation of the problem space. In the experiment, participants are tasked with two pre-tests at the beginning of the experiment. One of these is playing a game Tower of Hanoi for 20 minutes as well as taking the PISA problem-solving test. Tower of Hanoi is used to measure the rule application of the participants while the PISA problem-solving test is used to measure the transfer of problem-solving skills from video gameplay to novel scenarios. Subsequently, participants are randomly assigned to play one of the two video games in the experiment, i.e., a brain training video game CogniFit and a roleplaying video game World of Warcraft. This is followed by two post-tests, i.e., re-playing Tower of Hanoi for 20 minutes and another PISA problem-solving test.

Findings reveal that participants who play World of Warcraft are able to obtain better results for both the Tower of Hanoi and the PISA problem-solving post-tests after playing their assigned game for 20 hours compared to those who play CogniFit. This is interesting as it indicates that increased variation and complexity does not have necessarily reduce problem-solving performance. This study forms the key reference to our research.

3. Research design

3.1 Sample

A total of 15 students participate in the experiment. Most of the participants in this study are undergraduate students interested to develop their skills, knowledge and problem-solving skills. Three participants are omitted as they did not follow instructions correctly, attributing to incomplete data.

3.2 Methodology

The methodology for this study is similar to Emihovich’s (2017), but carried out fully online due to COVID-19’s movement control order. Emihovich’s study is chosen as the key reference as its objectives are the most similar to our research objectives, i.e., to compare the effects of brain training video game and roleplaying video game on problem-solving skills.

There would be a pre-test where participants will be tasked to complete the game Tower of Hanoi within 20 minutes. In Tower of Hanoi (Figure 2), the goal of the game is to move all of the disks from the first stand to the third stand (the stand on the far right). However, the players can only move one disk at a time and the upper most disk must be moved first before the lower disks can be moved. Also, the bigger disks cannot be placed on top of the smaller disks. Participants are encouraged to attempt the game as many times as they would like within the 20 minutes mark. They are asked to record the number of moves to complete each attempt and submit them through a questionnaire.

![Figure 2. Tower of Hanoi](image)

Once they have completed the pre-test, they would be randomly assigned to play one of two video games for an hour. The video games chosen for this study are Idle Supermarket Tycoon (Figure 3a) and Mario Kart Tour (Figure 3b). Idle Supermarket Tycoon is a video game that would encourage more thought
process from its players as they need to make decisions on the best way to invest their money to result in the best possible value gained. For *Idle Supermarket*, players are tasked with the management of a supermarket. They would need to buy and add new items for sale, and increase existing items for sale so that they would earn more profit or engage in other activities that would increase the revenue of the supermarket. *Mario Kart Tour* is a very fast-paced racing video game. For *Mario Kart Tour*, players would play as beloved characters from *Nintendo* franchises and race with them, players may also able to compete against their friends as well as other players that may be online.

Figure 3a. Screenshots of *Idle Supermarket Tycoon*

Figure 3b. Screenshots of *Mario Kart Tour*

4. Findings and discussion

The average is calculated from the pre-test and post-test scores of the participants. A lower average would indicate better problem-solving performance as it indicates lesser time is used to complete the task/achieve the goal. According to the data collected, those who play *Mario Kart Tour* have a much better performance in pre-test with a mean score of 49.67 and a standard deviation of 13.02. Those who play *Idle Supermarket Tycoon* have a pre-test mean score of 73.60 with a standard deviation of 26.17. During the post-test, the group which play *Mario Kart Tour* once again exhibit better performance with a mean post-test score of 39.23 and a standard deviation of 11.07. The group who play *Idle Supermarket Tycoon* have a post-test mean score of 49.78 and a standard deviation of 16. The difference in pre-post-test mean for *Mario Kart Tour* is 10.44 with a reduction in standard deviation of 1.94. The difference in pre-post-test mean for *Idle Supermarket Tycoon* however, is 23.82 with a reduction in standard deviation of 10.17. Hence, though students who play *Mario Kart Tour* consistently perform better in pre-post-tests, those who play *Idle Supermarket Tycoon* improve much more than those who play *Mario Kart*
This finding is consistent with Emihovich’s (2017) on the comparative strengths of role-playing games vs. brain training games.

Figure 4 illustrates the pre-test and post-test mean scores and standard deviation of each group.

Furthermore, *Mario Kart Tour* is more similar to the *Tower of Hanoi* with lesser number and types of variables to consider. In addition, the lesser number and types of variables to consider if viewed in terms of Shute, Lubin, Greiff, Zhao and Moore’s (2016) competency model’s 4 facets, i.e., “analyzing givens and constraints,” “planning a solution pathway,” “using tools and resources effectively and efficiently” and “monitoring and evaluating progress,” may provide hints/insights as to why time taken to complete is faster.

It is interesting that players are able to manage the increased cognitive load integral in strategy and role-playing games to problem-solve faster. This may indicate rule formulation/rule activation through multiple attempts. These findings confirm the possibility that increased multivariate variation and complexity do not necessarily reduce problem-solving performance, if there are frequent practices and reasoning based on these practices. The greater learning gain may also have resulted from greater motivation to develop rule formulation/activation when the problem is personally relevant/simulates real life challenges. If so, then the findings support that of Lee and Hughes’ (2019) earlier study on cognitive load theory with seniors; built on prior work with young adults.

### 5. Conclusion

This is an exploratory study intended to reconfirm Emihovich’s (2017) findings with a sample group of Malaysian students, using two different games. We have reconfirmed Emihovich’s (2017) findings on the comparative strengths of role-playing games vs. brain training games. Though cultures are different, findings are consistent. Furthermore, findings reveal that practice alone may not be sufficient to improve learning outcomes (problem-solving performance). Motivation to activate rule formulation and refinement in problem-solving, plays a key role too. There are however, limitations to the study. Due to MCO, the sample size is small and monitoring of participants is not carried out. Furthermore, there are limitations to self-report. Hence, we can only conclude that there are positive indications that more attention should be given to strategy and role-playing games, while interspersed with speed and brain training games, corresponding to the context and learning gaps at the point in time.
Acknowledgement

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References


Appendix 1

The Pre-Test
Pre-test
Before you start to play your assigned video game, you are required to first play a game called "Tower of Hanoi" which you can find online on the internet. A picture of "Tower of Hanoi" can be found below. You are required to play it for 20 minutes so be sure to time yourself when you are playing it, you can play as many times as you want so long as it falls under 20 minutes. Be sure to record the number of moves you managed to complete the game at each attempt.

If you have any questions about the experiment, you may email me at lingyuling50@gmail.com

* Required

A picture of "Tower of Hanoi"

Rules of "Tower of Hanoi"

players are tasked with transferring all the disks from tower 1 (the first tower on the left) to tower 3 (the third tower on the right) in the order that they were in the first tower before any moves were made. However, players can only move the topmost disk once at a time and the larger disk cannot be placed on top of the smaller ones. The number of moves it takes for players to complete the game are tracked at the top.
<table>
<thead>
<tr>
<th>Number of Moves</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>60</td>
</tr>
<tr>
<td>70</td>
</tr>
<tr>
<td>80</td>
</tr>
<tr>
<td>31</td>
</tr>
</tbody>
</table>

Your answer
Appendix 2
The Post-Test

Post-test

You are required to play "Tower of Hanoi" again once you had finish playing your assigned game. Like before, you are required to play "Tower of Hanoi" for 20 minutes, you may do as many attempts as you wish so long as it does not cross the 20 minutes limit mark. Be sure to record the number of turns you managed to complete the game after each attempt.

If you have any inquiries, you may email me at lingyulong50@gmail.com

* Required

What is your participant number *

Choose

Choose your reward. *

- RM10 GrabFood voucher
- RM10 Steam Wallet Code
- I don't want any

Enter in your email address. (you are required to enter your email address for the collection of your reward, you reward will be given out by July 12. Please ensure your email address is entered correctly or your reward will be forfeited.)

Your answer
Augmented Reality Maze Game with Google Cardboard for Child Edutainment

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*chiensingl@sunway.edu.my

Abstract: Students need to develop adequate problem-solving skill to keep up with studies. This project aims to improve primary school students’ problem-solving skills as these need to be inculcated from young. Such training may also strongly impact interest in learning in the future. The application developed also targets hand-eye coordination skills. Higher Order Thinking Skills targeted are such as analysis, problem-solving, decision-making and memory skills. The results indicate that through multiple gameplays, better results are recorded. There are differences arising from students’ power of observation, analysis, uninformed and informed hypothesis testing, serendipity and courage in thinking out of the box. However, due to the small sample size, more needs to be investigated to confirm observations, and the need to increase the difficulty of the problem for more sustainable outcomes.

Keywords: Augmented Reality, maze game, Google cardboard, child, edutainment

1. Introduction

The marketplace and consequently, educational institutions, have increased the need for problem-solving skills. In schools, such skills are referred to as Higher Order Thinking Skills (HOTS). HOTS correspond with the revised Bloom’s taxonomy (Anderson & Krathwohl, 2001) illustrated in Figure 1. Since admission to higher levels of education depend on performance in HOTS, children with inadequate HOTs and problem-solving skills would face difficulties keeping up with their studies.

Figure 1. Bloom’s revised taxonomy

Hence, we aim to improve the child’s (ages between 6-12) problem-solving (analytical and evaluation) skills from young before they step into secondary school. Learning and experiences are additive. Hence, they should be able to perform better (Magsino, 2014; Brynes, 2016) and subsequently, to
adapt and perform better in educational institutions and eventually, the workplace.

The scope for this project is an Augmented Reality (AR) Maze Edutainment game. AR and a 2D game enable tactile and immersive visual interactions. However, AR extends from a 2D game due to the superimposition of information on top of the actual object/image. Hence, they do make a difference that may not be possible in a 2D game, such as to enable students to solve problems in different ways.

A maze game is chosen because the game can trigger students’ hand-eye coordination, memory and judgement. The project is developed using Unity 3D and Vuforia plugin. A single visible ball is superimposed in the virtual maze. The user can use his/her hands to coordinate and rotate the maze to guide the ball’s path and rotation. A timer is superimposed at the top of the maze to keep count of the time taken to solve the maze puzzle.

2. Literature review

2.1 Maze game for child edutainment in virtual reality

Lack of problem-solving skills is the main obstacle to students improving academically. This study uses game-based education because games make learning fun, help students to pay attention and stay focused throughout the whole process (Prensky, 2001; Brynes, 2016). This is important because our targeted users are primary school students. It is also true, for the elderly (evSky, 2008).

A maze game is chosen because it can significantly improve HOTS. The child must trigger his executive function skills to derive and conclude a solution for the maze. Examining helps problem comprehension as the child needs to visualize problem scenarios more effectively. He/she also needs to consider all sorts of criteria and decide which criteria to use prior to decision-making. An area which has become more popular is visual motor integration for pediatric therapy (Mathews, 2019).

Besides helping to develop skills in examining the problem and in identifying possible solutions, maze games help with memory. For example, if the child is stuck at a dead-end in the maze, he/she needs to recall the steps that have brought him/her to his/her current position and reverse his steps to return to a previous position to look for another possible solution, similar to informed search strategies. With better memory, is better efficiency in dealing with the problem.

However, ease of use/maneuver are important for technology adoption. For example, the Augmented Reality project in Figure 2, requires two hands to comfortably rotate the maze. One hand holds the phone and the other hand the maze. This makes it difficult to rotate the maze. The ease of use depends on design and objectives. Hence, we surmise that the game is more suitable for those who are used to object manipulation using both hands and that the complexity of the maze is lower.

2.2 Virtual Reality (VR) maze-related game

Virtual Reality (VR) maze games can project objects for students to interact with the maze, thus making possible improvements in planning, strategizing, understanding, responding, formulating criteria and decision making (Prensky, 2001). In the virtual world with the maze map, the child moves the ball by rotating the maze map using their hands. Brynes’ (2018) findings with printable mazes also indicate positive outcomes in handwriting.

Most existing VR maze games are from a first-person view, where the player is in the maze, and has to find his/her way to achieve the objective. These projects are helpful in training Higher Order Thinking Skills. However, these projects usually require Oculus Rift and a controller to virtually “move” the player inside the maze. Oculus Rift is not budget-friendly, especially for primary-school students. A project developed by Tibog (2017) (Figure 3) is very interesting but may be too complicated for the targeted users, i.e., primary school children. Besides the inherent complexity of the game, both hands are required to rotate the maze. It is also necessary to have a stationary Web camera.
From the above review, we surmise that the game should be hands-free and enable the user to view the environment for safety reasons. We thus refer to EverXFun (2017), and the VR maze game with Google cardboard in Figure 4. As illustrated in Figure 4, the game is played by rotating the whole physical cardboard to maneuver the ball from start to finish, while avoiding the holes. The maze game is completely physical, except for the “lives” at the top-left corner.

3. Methodology

The methodology used in this project is Rapid Application Development (RAD) (Figure 5a) because the vital functional requirements are not set or fixed. The flowchart is presented in Figure 5b. A simplified technology acceptance test based on Davis, Bagozzi and Warshaw’s (1989) Technology Acceptance Model (TAM) is used in the design and tested in the beta testing. Constructs in TAM are ease of use, usefulness, attitude, intention to use and behavioral intention to use.
4. Requirements Planning

This involves identifying the functional and non-functional requirements for children using Augmented. Examples of considerations are the environment of the children while using Augmented, how the children use Augmented, how the game is played, how to improve eye-hand coordination in the game.

Ideally, in terms of the location/environment, the user should be in an indoor environment without any nearby obstacle. Furthermore, the location needs sufficient lighting for the camera to scan the maze. In terms of set-up, the user needs to wear the Google cardboard with the application to view the maze. Functional requirements are presented in Table 1a and non-functional requirements in Tables 1b, and 1c.

<table>
<thead>
<tr>
<th>Functional Requirements</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display the maze</td>
<td>A physical picture is used as a trigger to display the maze in the app. The application uses camera to scan the physical picture and displays the maze in the application.</td>
</tr>
<tr>
<td>Display the ball</td>
<td>When the maze is displayed, the ball shall be displayed as well in the application. The ball must be spawned at the start point (blue space).</td>
</tr>
<tr>
<td>Maze corresponds to physical picture (image tracking)</td>
<td>When the physical picture rotates, the maze in the application rotates.</td>
</tr>
<tr>
<td>Ball contained in the maze</td>
<td>The ball shall not fly around or outside the maze.</td>
</tr>
<tr>
<td>Ball movement responds to the change of state of maze</td>
<td>The ball shall land on the maze and is able to move when the maze rotates or changes angle.</td>
</tr>
<tr>
<td>Ball and maze blocks have collision</td>
<td>The ball and maze blocks should have collision so that the ball does not pass through the blocks. The ball can only move on space without the maze blocks.</td>
</tr>
<tr>
<td>Game ends when the ball reaches end point</td>
<td>The game ends when ball reaches the end point.</td>
</tr>
<tr>
<td>Open timer</td>
<td>The timer is displayed and starts as soon as the maze and ball are displayed. The timer starts from 0 and there is no time limit. The timer should stop when ball reaches the end point.</td>
</tr>
<tr>
<td>Display the timer</td>
<td>The timer stored of the current game will be displayed at the end of the game.</td>
</tr>
</tbody>
</table>
Table 1b. Non-functional requirements

<table>
<thead>
<tr>
<th>Non-Functional Requirements</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability</td>
<td>The game should be able to run on Android and iOS.</td>
</tr>
<tr>
<td>Safety</td>
<td>The system should not have actions that can potentially harm the user.</td>
</tr>
<tr>
<td>Usability</td>
<td>The system must be easy to use.</td>
</tr>
<tr>
<td>Performance</td>
<td>The game difficulty should be triggering higher intensity of HOTS that is suitable for primary school students.</td>
</tr>
</tbody>
</table>

Table 1c. Non-functional requirements for the ball

<table>
<thead>
<tr>
<th>Non-Functional Requirements</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliability</td>
<td>The ball should be contained in the maze and not randomly float or fly around.</td>
</tr>
<tr>
<td>Speed</td>
<td>The ball should have relevant speed to the rotation and tilt of the maze.</td>
</tr>
<tr>
<td>Visibility</td>
<td>The ball should be easily seen and found in the maze. (include different color or pattern to the ball)</td>
</tr>
</tbody>
</table>

5.1 5. Design

An enhanced AR maze game mounted to Google cardboard similar to Figure 4 is developed, with the above requirements in mind. Since the game is in virtual space, it can be played anywhere. However, it is better for the child to play indoors and in a static location due to safety reasons. A static location is also recommended for better immersive experiences and focus. Moving around can cause distraction and also affects the tracking of the marker.

The Higher Order Thinking Skills (HOTS) to be satisfied are analysis and evaluation. The maze game design (Figures 6a, 6b) involves creating a square-sized maze that will pop out from a physical image. The physical image is to be held physically by the child. A ball is placed in the virtual maze for children to maneuver from a start point (blue block) to the end point (green block). The ball will spawn in the blue space, and whenever the ball touches the green space, the game is ended. Maneuvering the ball requires hand-eye coordination where the child rotates the physical image. When the game starts, a timer will start counting and stops when the game has ended. The time will then be stored in the game to be displayed.

The expected ball physics are:

a) Ball maneuver corresponds to how the map rotates
b) Ball’s movement considers speed (inertia, speed, slowing down, etc.)
c) Ball has collision.

The expected gameplay outputs are:

a) Ball spawn in the spawn point (blue space)
b) Ball is contained in the maze (do not randomly fly off the maze)
6. Development

6.1 Prototypes 1 and 2

The objective is to build a prototype for pilot testing/feedback purposes and which can be re-designed easily. The prototype created is simple and straightforward with respect to functional requirements. In the prototype, a maze is designed and built in 3D Unity. The maze can only spawn when a specific picture is found through the camera of the application (Augmented Reality). A ball is spawned at the start as well when the maze is spawned. In the early stage of prototype testing, the physics and movement of the ball reacting to the rotation of the maze are tested.

For this maze-game, marker-based augmented object is the priority for choosing the SDK. A marker is used for this project so that the child has a physical item for “hands-on” control and to rotate the map. Although popular SDKs such as ARCore, ARKit and Vuforia all have the ability to create a marker-based augmented object, Vuforia is chosen for its better performance in 3D tracking of the marker (Design, 2017). This application also targets availability. ARCore is compatible with certain Android devices while ARKit is specifically for iOS devices. Vuforia has the advantage of being compatible with Android and iOS.

7. User testing feedback

7.1 Prototype 1 and 2 user testings

Feedback cannot be obtained via interview or questionnaire as the children are too young to provide feedback without stressing them. Hence, the prototyping approach is used. The initial prototype is presented to 10 testers (teenagers and adults aged between 15 to 20) to verify the functionality of the system and collect comments. The comments are then analyzed and filtered to refine the functional and non-functional requirements. The 10 testers agree that the prototype is playable. Categorized comments collected from prototype 1 (some comments are similar across users) and observations/changes made are presented in Table 2.

Table 2. Categorized comments collected from prototype 1 (some comments are similar across users) and observations/changes made.

| Comment 1: Nice, I can see the environment of my surrounding when playing the game, should be safe, I guess. | Justified a non-functional requirement Safety. By enabling the virtual world to view the current surroundings is a good safety feature so that the user is aware of the space they are currently at. Such feature can limit the user’s movement to |
decrease risk of hitting or hurting themselves in the space.

Comment 2: The game needs more effects that excites the kids, like some glowing or flickering effects.  
Realized the graphical/visual requirement is important to excite users.

Comment 3: I notice the ball flies and restart to the start point randomly, can you fix it?  
Reliability becomes more important - a non-functional requirement specifically for the ball physics. The ball should not be unstable during gameplay.

Comment 4: The ball moves a little too fast in my opinion.  
Speed, a non-functional requirement specifically for the ball physics, is very subjective to each users’ preference. However, a suitable and relevant speed for the ball must be decided in the game. Finally, the speed of the ball is set to correspond with the rotation and angle of the maze.

Comment 5: I find it hard to see where the ball is, the ball color sometimes blends into the walls.  
Comment highlights the importance of visibility, a non-functional requirement specifically for the ball physics. Otherwise, during gameplay, the child may lose track of the ball as the ball camouflages into the wall blocks. The color of the ball is thus changed to light blue.

For the second user testing, changes based on user feedback are: a) addition of audio when the maze appears or disappears in the application, b) creation of a higher difficulty level for the maze.

7.2 Beta Testing (Technology Acceptance Model and HOTS) and discussion

7.2.1 Beta Testing (Technology Acceptance Model)

The targeted users for beta testing are primary school students. Prototype 1 is tested on 5 primary school students from different schools. Testing is scheduled individually with each student. Upon scheduled testing with the students, they are given the maze, the application and Google cardboard and asked to play the maze game 3 times (reach the end goal 3 times). However, no instructions are given to them as to how to play the game. This is to test the “perceived ease of use” construct in the Technology Acceptance Model. The students find the game easy to use.

7.2.2 Beta Testing (HOTS: a) analysis/evaluating? b) memorization? c) visual motor (eye-hand coordination represented culminating in speed as performance)

Table 3 presents the results of 3 performance tests by the 5 primary school students in terms of their completion time (in secs):

<table>
<thead>
<tr>
<th>Primary School Student</th>
<th>Test 1</th>
<th>Test 2</th>
<th>Test 3</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>32.29</td>
<td>26.19</td>
<td>25.22</td>
<td>27.90</td>
</tr>
<tr>
<td>2</td>
<td>40.44</td>
<td>39.51</td>
<td>33.41</td>
<td>37.79</td>
</tr>
<tr>
<td>3</td>
<td>44.12</td>
<td>20.22</td>
<td>18.51</td>
<td>27.62</td>
</tr>
<tr>
<td>4</td>
<td>33.37</td>
<td>22.10</td>
<td>140.55</td>
<td>65.34</td>
</tr>
</tbody>
</table>
7.2.3 Observations

After the beta testing phase, several questions regarding the thought process of the gameplay are asked and observations made. These answers are obtained by analyzing the gameplay of the primary school students and their feedback/thought processes during gameplay.

Student 1 has played the game seriously with the purpose of self-improvement and obtaining higher score. This implies that the student thinks about the improvement in the time taken for the ball to reach the finish point more quickly. To improve the high score, he questions the physics of the ball and finds that the ball moves at different speed when rotating and tilting at different angles. Consequently, the student manages to solve the problem by making good use of the speed of the ball to reach the finish. The game has triggered problem-solving skill and evaluation and understanding skill for student 1. If given a more difficult game, he is expected to perform well.

Student 2 completes the game more slowly than a majority of the students. Also, during his gameplay, there is a noticeable lack of hand-eye coordination. The student mentions he knows the route to the finish but is frustrated when maneuvering the ball to the finish. During the 3 runs, he manages to improve his completion time after realizing that the problem he has to solve is the rotating and tilting as the physical maze affects the movement of the ball. Since hand-eye coordination involves processing or performing an action and evaluating the result, this game can improve his visual motor skills in the long run, allowing him to interpret actions and consequences more effectively.

Student 3 is the fastest to complete the game in 3 runs. The first run is slow as he does not make much evaluation of the routes. He constantly moves the ball to various routes but recovers it quickly. This student actively triggers his memory; remembering and identifying routes used and not used. After completing his first run, he uses the same route for the second and third runs. This student evidences slight improvement in his problem-solving skill when the ball is stuck in an area. Though he does not examine and evaluate much, his memory seems to improve most.

Student 4 finds 2 different routes to finish the game on the first and second runs. On the third run, he explores the map and watches the reaction of the ball to the maze. Instead of finishing the game normally, during his gameplay, he notices the ball is able to leave the maze (note: ball is contained inside the maze, it is not expected to leave the maze). There should be a bug that he encountered during gameplay. Therefore, he tried shaking the maze vertically and horizontally, tilting and rotating aggressively. He encounters the problem of forcing the ball out of the maze (exploiting). From this point, the game improves his thinking-out-of-the-box skill and examining skill.

Student 5 is adventurous in the gameplay. For the first run, he manages to maneuver the ball quickly to the finish. For the second run, he chooses to go through other route and becomes stuck in an area. When the ball is stuck in an area, he is required to bring the ball back to its previous position where other possible routes can be chosen. However, he manages to remember the steps, rotation and bring the ball back to a previous point to pursue other possible routes. The completion time for the second round is more than the first. The game has triggered his problem-solving skill, memorizing and examining skill while bringing the ball back to previous point. By increasing the complexity of the maze, it is expected that the student will be able to improve his HOTS more significantly.

Students 1 and 2 have developed similar problem formulations and hypotheses and have experimented with rotating and tilting at different angles. Student 3 remembers/recalls successful routes and doesn’t explore other routes. His strategies are similar to those of a chess player. Student 4 uses trial and error. Student 5 remembers successful routes to a certain point and backtrack when unsuccessful to explore other routes. Hence, though all students have analyzed and evaluated the problem in trying to solve the problem, differences arise from observation, uninformed and informed hypothesis testing and serendipity in thinking out of the box. This reconfirms prior findings summarized in Lee and Lau (2015) and Lee and Wong (2015; 2018) on the importance of problem/hypothesis formulations. It also hints that such results can be predictive in the long run.
8. Conclusion

In conclusion, primary school students sometimes have difficulties keeping up with the current education level due to HOTS implementation in educational institutions. We are interested in several HOTS such as analysis and evaluation as these influence decisions making during problem-solving. Primary school students with inadequate problem-solving skills may face even greater gaps in knowledge in the future.

For this project, an edutainment augmented reality maze game specifically targeted to primary school students to improve their problem-solving skills is developed. The end of the game is achieved by moving a ball from start point to an end point within the shortest time possible. The game has provided students more experience in decision making and problem-solving. However, due to the small sample size, more needs to be investigated to confirm observations and for more sustainable outcomes. Future work may involve investigating whether the skills acquired in playing this game would subsequently translate to higher order thinking skills in other educational contexts and extension to VR games.

Acknowledgement

We would like to thank the anonymous reviewers for their constructive comments and suggestions. This paper is extended from the first author’s capstone project completed July 2020 in Sunway University, Malaysia, with the second author.

References


Integration of Face Detection and Augmented Reality into Human Anatomy Education

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*bongmf@utar.edu.my

Abstract: This paper proposes an interactive augmented reality (AR) application to aid medical student in learning the human anatomy. Students will be able to take a photo of their friend using the camera in real time. Then, the system will detect their friend’s face and relocate the human anatomy to the approximate position of their friends inside the augmented reality application. With this application, the learning process will be fun and could help in improving the student’s retention in their studies while boosting their motivation in getting better in their learning. Besides, teamwork will be fostered along when the students are learning in a group. The experiment is conducted on the first-year medical related student in Universiti Tunku Abdul Rahman (UTAR). The result shows that there are 75% of the students agree and strongly agree that this application is able to facilitate them in the understanding of human anatomy. Based on the survey, it is concluded that the students are satisfied with this application and agreed to the effectiveness of Augmented Reality in their learning process.

Keywords: Augmented Reality, face detection, educational game, serious game, human anatomy

1. Introduction

Today’s students are growing up in the information and communication environment era and traditional teaching and learning methods are becoming difficult to attain their interest (Bi, M. et. al., 2019). Students are able to obtain the knowledge in different ways, for example to study from books, laptop, desktop, tablet, smartphones and other electronics appliances (Lee, K., 2012). Although the choices to obtain knowledge are highly reliant on individual preferences, but the traditional way of getting knowledge from books is not a good choice for human anatomy studies as it can only displays in two dimensional.

Integrating the AR into teaching and learning methods can attract the student’s attention. Besides that, implementing AR into education can make studying more interactive, less stressful and more productive. (Huang, T. C. et. al., 2016).

AR captures the real environment as the background and virtual assets are then added into the captured scene such as button, text, label, 3D models, 3D animations, 2D images and so on. Based on the results found by Wang, M. et. al. (2018), AR had proved its efficiency in various pedagogical perspectives, which are instructionism, constructivism and collaborative learning.

In AR applications, it can be divided into two types, marker and markerless Augmented Reality. Both types of AR are widely used in education field. Juanes, J. A. et. (2014) introduced a marker based augmented reality with the human anatomy contents where they scan a marker then display the relevant human anatomy information. There are also a few researchers who applied markerless AR such as Chien et. al. (2010) and Kegerlmann D. et. al. (2018) in human anatomy studies as well.

Based on the statement of Yung, R., & Khoo-Lattimore, C. (2019), due to financial problem, AR in education is hard to implement in school. In Malaysia, primary school and secondary school students are not allowed to bring smartphones to attend the school. However, the students in higher education do not facing this kind of problem because they are allowed to bring their smartphones to campus.

In this paper, an AR application called “capture your friend with human anatomy” (CapAnatomy) is
introduced to help first year medical students in memorizing the human anatomy. This application is able to rescale the virtual human anatomy based on the estimate location of the body to help the students to better understand the location of that particular human anatomy. This helps students in understanding the relationship of spatial between the real person and virtual human anatomy. When the student is moved while the application is targeted on him, the virtual human anatomy will move accordingly. The real or the physical virtual model of human anatomy is expensive and impractical for students to own it, but using AR application will allow them the access to the resources with lower cost and portability.

1.2. Research aims

The aims of this research are to apply interactive Augmented Reality application to helps medical students attain more focus, learning in less stressful condition and interactively to understand the human anatomy.

2. Methodology

This application is developed using Unity game engine and OpenCV library. OpenCV is used to detect the user’s position in the camera and then find the approximated spatial for human anatomy. Firstly, the face of the user’s is detected and it can be the user himself or his/her friend. Secondly, the calculation is carried out to find the approximate location of the human anatomy based on the ratio of face in the camera view. The size of the human anatomy will be rescale based on the ratio of face. Then the user is required to answer the quiz for the anatomy parts after 10 minutes by pressing the next button in the application. Then quiz questions will be ask regarding the human anatomy studied in the previous section. The score is calculated when the submit button is pressed in the application after they finished answering the questions. Figure 1 refers to the flowchart of the overall prototype for this system.

This AR application is a prototype and concept version only. Therefore, only digestive system is available at the moment. The application is being used by the students to test its effectiveness in teaching and learning process. A total of 41 respondents from UTAR have undergone the test. They are all first-year students from the Bachelor of Nursing, Bachelor of Physiotherapy and Bachelor of Traditional Chinese Medicine.

A Google form survey which incorporates their learning ways, satisfactory towards the AR applications, feeling and their experience with augmented reality are done by those students that undergone the tests and the results are studied.

Figure 2 refers to the prototype of the application. An input field, buttons, face detection technique, camera and 3D human anatomy’s model are used.
Start

Webcam

Front Camera? Yes

Front Camera (capture user)

Face Detection (OpenCV)

Relocate and rescale the human anatomy

Display the human anatomy and the user interface for quiz.

Submit button pressed?

Yes

Calculate the scoring

Display the result

End

No

Back Camera (capture their friend)
3. Results and discussion

From the results obtained, 80 percent of the students had never experienced Augmented Reality-based learning methods. In Malaysia, our education methods are conventional because the educators lack technological skills especially among older generations. The result is shown in Figure 3.
There are over half of the respondents which is 58% spend more than two hours using electronic devices for learning purpose. This number is considered low for the current generation of university students. The result is shown in Figure 4.

There are 73.2% of the respondents agree and strongly agree that the AR application is able to facilitate their understanding toward the human anatomy and 19.5% of the students had neutral agreement on this. At the end of the tests, most of the students can score 100% for the quiz. The result is shown in Figure 5.
Figure 5. This pie chart shown if the application is able to facilitate their understanding of knowledge.

There are 70.7 percent of the students who admitted that this application brings them enjoyment in their learning process. It is important to make learning fun. It allows students to engage in the contents studied better and less stressful. The result shown in Figure 6.

Figure 6. This pie chart shown if the application is able to promote enjoyment in their learning process.

A total of 68.3 percent of the respondents are willing to do self-learning if they are given this application. The integration of Augmented Reality in education is able to motivate the students in doing self-learning. The result is shown in Figure 7.
Figure 7. This pie chart shown if the application is able to develop their ability in self-directed learning.

There are 32 out of 41 respondents who agree and strongly agree that this application is able to consolidate their memory of the contents of the subject. As we all know that, human anatomy is a topic that requires high level of cognition. The result is shown in Figure 8.

Figure 8. This pie chart shown if the application is able to consolidate their memory of the contents of the subject

The average score obtained by all the respondent after answering the quiz using the AR application is 80%. This shows that the application is effective in the learning process.
4. Conclusion

Based on the survey filled by the respondents from medical student from Universiti Tunku Rahman (UTAR), this augmented reality application is able to help them to consolidate the memory, motivate them to self-learning and have fun in their learning process. Besides, almost everyone has a smartphone today and the students are more willing to study if their learning resources are more portable compared to books which are bulky to carry. Therefore, it can be concluded that the integration of augmented reality in the subject of high level of cognition is very effective and this application should continue to be developed to aid students in their learning process.

References

Abstract: This study aims to explore how to enable more efficient strategizing in a less computation-intensive yet data-driven manner. The methodology would serve as a preliminary means to identify key factors prior to further data mining. With data set for Quality Education from 2013-2018 obtained from existing literature and meta-analysis literature on disruptive technologies, we use three techniques to discover key important factors leading to the evolution/development of disruptive technologies from 2013-2018. Text processing is used to generate word clouds. Subsequently, word cloud data is fed to project management tools (Pareto chart and Ishikawa diagram) to discover in greater detail, associative key influencing factors. Significance lies in the less computation-intensive yet data-driven methodology, which falls under hybrid semi-automated mining; acknowledging the contribution of human heuristics. We hope this hybrid semi-automated method would provide a preliminary means to gauge what would be interesting for further mining.

Keywords: Word Cloud, Pareto, Fishbone, text mining, analogical heuristic approach to less computation-intensive semi-automated inferences

1. Introduction

The United Nations’ Development Program (UNDP) is one of the leading organizations working to fulfil the Sustainable Development Goals (SDGs) by the year 2030. SDGs have been established in 170 countries and territories focusing on poverty alleviation, democratic governance and peacebuilding, climate change, disaster risk, and economic inequality.

Corresponding with the SDGs, technology is constantly changing, becoming more pervasive and ubiquitous. Hence implementing new and existing technology in various aspects of life as well as discarding technology that are unadaptable over time is critical in order to strategize and manage socio-technological design and development more effectively.

1.1 Research aims

Friedewald and Raabe (2011) define disruptive technology as “a newly developed innovation that creates more incentive and value than the existing technology.” It drastically changes day-to-day activities as well as business and economic output, creates new players and new markets while marginalizing old ones, and delivers dramatic value to stakeholders who successfully implement and adapt to the innovation. Therefore, disruptive technologies provide dramatic improvements to current product market paradigms and produces physical products and services that initiate new industries”.

We will analyze trends across 2013-2015 and 2016-2018 for SDG 4 Quality Education. The aim is to identify key causes and effects and thus generate insights to enable appropriate management of technological innovation. By identifying key factors, we improve scope and cost management and are more likely to reduce risk. Consequently, organizations would be better prepared to meet the challenges of current and future trends across the industry. This applies to both academic and corporate institutions.
1.2 Research Questions

Thus far, there are many data analytics tools in the market. However, these can be quite expensive for the small and medium enterprises. The analogical approach we adopt for this study is aimed at hybrid semi-automated mining. It is popular due to its flexibility to tweak parameters at different checkpoints e.g. in multi-level data mining, to result in better outcomes. Examples of earlier studies are Lee and Singh (2004) studies on multi-level self-organizing map-principal component analysis for adaptive learning and Kiu and Lee’s (2007) studies on self-organizing map-k-means and for ontology mapping and merging.

For this study, the inspiration to combine Word Cloud with Pareto chart and Fishbone diagram is from Pinto’s (2018) textbook on project management in 2018. Our research questions for this study concerns the evolution of Disruptive Technologies from 2013-2015 and 2016-2018. We are interested in:

- What are the major factors driving the evolution and development of disruptive technologies for SDG4 Quality Education using text extraction, Pareto analysis and Ishikawa diagram? (This first research question is quite broad but analyses are possible as some of our references are meta-analyses).
- What insights can we gain from these tools/instruments in comparison with existing literature? Will they be the same or can the process be simplified?

2. Related work

2.1 Project management tools (Pareto chart and fishbone diagram)

The Pareto Principle is a simplified version of the Mathematics behind Pareto distribution. Pareto Principle uses 80-20 as a rule of thumb which states that for many phenomena, about 80% of the consequences are produced by 20% of the causes (Dunford, Su, Tamang, & Wintour, 2014). In other words, the “vital few” items occupy a cumulative percentage of 80% while 20% is occupied by “useful many”. The total frequency results in 100%. This is often used in Management, Economics, Business, Computer Science and Human activity to enhance productivity and decision making. Pareto Analysis is an application of the Pareto Principle. Classified as a quality control, cause and effect technique, it ranks data classifications in descending order from the highest frequency of occurrences to the lowest frequency of occurrences.

The Ishikawa Diagram (Coccia, 2017) also known as Fishbone Diagram, is a technique used to identify the problem, the major factors involved, possible causes and the root cause on issues of quality. The bevel line segments in the Ishikawa Diagram represent the distribution of the multiple causes and sub-causes which produce them. The root cause is partly determined through group participation and group knowledge of the process. Such discussions help determine areas where data should be further collected.

2.2 Data analytics, text extraction tools

In this study, we look at text mining. Defined as "the process of finding useful or interesting patterns, models, directions, trends, or rules from unstructured text," text mining is a multidisciplinary field. It involves information retrieval, text analysis, information extraction, clustering, categorization, visualization, database technology, machine learning, and data mining. However, text mining is more complicated due to its unstructured nature.

3. Methodology

We aim to gain insights on the evolution of disruptive technologies between 2013-2018 and to compare these with existing literature. We surmise that by comparing technology-enhanced human heuristics with actual literature, we would be able to confirm the potential of our heuristically-driven approach, serving as
a rough guideline/hint of interesting areas for further mining with other models/methods.

3.1 Research design

This study is conducted by making use of simple text extraction and Project Management cause - effect tools. Data for this research is collected through the combination of research, conference and journal articles to create a literature review data set. The sources of data are from journal articles extracted from Science Direct, IEEE Explore, Lancaster University One Search. These references are presented in Table 1.

Table 1. References used in this paper.

<table>
<thead>
<tr>
<th>Area</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analytics</td>
<td>Daniel (2014); Luckin, Holmes, Griffiths, &amp; Forcier (2016); Murphy, Redding, &amp; Twyman (2016);</td>
</tr>
<tr>
<td></td>
<td>Wong, Vuong, &amp; Liu (2017); Salloum, Al-Emran, Monem &amp; Shaalan (2018); Viberg, Hatakka, Bälter, &amp;</td>
</tr>
<tr>
<td></td>
<td>Mavroudi (2018); Howell, Roberts, &amp; Mancini (2018)</td>
</tr>
<tr>
<td>Augmented reality</td>
<td>Antonioli, Blake &amp; Sparks (2016); Toledo-Morales, &amp; Sanchez-Garcia (2018)</td>
</tr>
<tr>
<td>Virtual reality</td>
<td>Getso, &amp; Bakon (2017); Hu &amp; Lee (2017)</td>
</tr>
<tr>
<td>Mobile learning</td>
<td>Göksu, &amp; Atici (2013); Domingo, &amp; Garganté (2016); Hefflin, Shewmaker, &amp; Nguyen (2017)</td>
</tr>
<tr>
<td>Cloud computing</td>
<td>Pardeshi (2014)</td>
</tr>
<tr>
<td>Ubiquitous computing</td>
<td>Friedewald, &amp; Raabe (2011)</td>
</tr>
<tr>
<td>Gamification</td>
<td>Dicheva, Dichev, Agle, &amp; Angelova (2015); Simões, Redondo, &amp; Vilas (2013)</td>
</tr>
<tr>
<td>Policy</td>
<td>Roberts-Mahoney, Means, &amp; Garrison (2016)</td>
</tr>
<tr>
<td>Open edu resource</td>
<td>Wiley, Bliss, &amp; McEwen (2014); Scanlon, McAndrew, &amp; O'Shea (2015)</td>
</tr>
</tbody>
</table>

Table 2 describes the techniques used and the objectives these techniques hope to achieve.

Table 2. Techniques used and their objectives

<table>
<thead>
<tr>
<th>Technique</th>
<th>Purpose</th>
<th>Objective of technique</th>
</tr>
</thead>
</table>
| Text Mining                       | Data Extraction                | • Process unstructured (textual) information collected from the combination of conference and journal articles. 
• Clean and Extract meaningful indices from the text to use for analysis. 
• This process will be done using R programming. |
| Word Cloud                        | Data Visualization             | • Depict key terms. 
• Identify high frequency key terms. |
| Pareto Analysis                   | Data Analysis                  | • Identify the cause-effect factors. 
• Narrow down to most significant causes. |
| Ishikawa Diagram                  | Data Visualization and Analysis| • Analyze broad causes by looking at specific factors. 
• Categorize the potential causes and effects, hence identifying factors and sub factors contributing towards disruption. 
• Analyze data frequency of cause and effect. 
• Analyze the root cause. |
| Word Cloud + Ishikawa Diagram + Pareto | Data Analysis | • Identify common and if there are, unique factors between the top two from the Pareto Chart and Fishbone. 
• Compare results with existing literature to identify whether there are insights which are comparable and insights which literature did not detect. |

Text mining is carried out using R as a mining tool to process text in order to detect key terms of major relevance. Processes in Text Mining using R are:

1. Create separate text files for the year ranging from 2013-2015, 2016-2018 for “Quality Education” and load into R.
2. The text is then filtered, parsed and pre-processed using Tokenization.
3. Convert the text to lowercase, remove numbers, comma of the text document and stop words such as “a”, “of”, “the”, “is”, etc.
4. Text is then transformed into a Vector space, thereby allowing us to detect most frequent words and to further generate the word cloud.

4. Findings

4.1 Generated data (2013-2015)

The generated Word Cloud is presented in Figure 1. The Word Cloud depicts the most frequent terms which are considered to be the most relevant terms. Figure 1 shows “learning” “cloud” as the most frequent term and therefore the most impactful with regard to disruption. Other high-frequency words in the Word Cloud are “information,” “students” and “data.” This implies that from 2013-2015, the driver behind technology disruptions is due to the need for information and more easily accessible management of data e.g. the cloud.

Pareto Analysis in Figure 2 based on the same dataset illustrates the frequency and the line from left to right, the cumulative percentages. The almost comparable frequency of terms for “cloud”, “mobile” indicates the trend and direction for innovation as early as 2015 in managing data/information, catering to bigger audiences with computing devices.

Figure 1. Word Cloud for 2013-2015 data

Answering the question “why does this happen?” we dig deeper, to better understand what is driving disruption in the Industry technology. The Ishikawa diagram in Figure 3 shows the sub-factors of “learning” as affected by education, computing, cloud, research, services, online, resources, higher, students. These reflect the concerns faced by institutions of higher learning, which need to carry out online activities such as research as well as academic services with suitable resource management. Similarly, “Cloud” affects research, education, learning, services, and information but highlight the cost factor, supporting the key concern with resource management.

As a result of combining these tools, the extension of learning accessibility made possible by online services, and the cloud’s higher manageability and cost-effectiveness highlight the two key main technology drivers.
4.2 Generated data (2016-2018)

The categories, frequencies and cumulative relative frequencies from the Word Cloud generated from the 2016-2018 dataset is illustrated in Figure 4. Figure 5 presents the generated Word Cloud. In Figure 5, “learners,” “teaching” and “learning” as the most frequent terms and therefore the most impactful with regard to disruption. The corresponding Pareto Chart is illustrated in Figure 6. There appears to be a shift to student-centered learning and “technology” as assistive.
The Ishikawa diagram in Figure 7 shows “learners” is affected by learning, commitment, model, feedback, information, students, education, mobile, time where they impact application of disruptive technology towards education as contributing factors.

“Teaching” is affected by enhanced, education, feedback, impacts, school, personalized, commitment. These imply that personalized learning with avenues for feedback is gaining more interest in creating more commitment and impact to learning beyond greater accessibility and data management in the cloud (findings from the 2013-2015 data). There are also interests in using or developing “models” of teaching-learning to enhance education. A key factor underlying these needs is lack of time.

This methodology is repeated for the healthcare domain and findings are consistent with existing literature, but faster due to its simplicity.
4.3 Limitations of the study

This method has a certain degree of subjectivity as the data entry is partly dependent on human assessment/heuristics as its aim is only as a preliminary guide, not a full-fledged mining tool.

5. Conclusion

Problems and challenges can cause major technology product paradigm shifts or create entirely new ones. We use text extraction to feed into a Word Cloud generator and subsequently the frequency of terms from the Word Cloud become the data fed into the Pareto Chart and Ishikawa fishbone diagram. Consequently, we are able to identify major factors driving innovation for SDG4 Quality Education from 2013-2015 and, from 2016-2018. Our findings are consistent with literature and the general trends at that particular period of time but highlight associative factors in a simpler manner. Hopefully, with this less computation-intensive yet data-driven approach, with human input, it can serve as a rough guideline/hint of interesting areas for further mining with other models/methods and scoping, time, cost and risk management will become easier and faster.

Acknowledgement

We would like to thank the anonymous reviewers for their constructive feedback. This paper is extended from the second author’s capstone project completed Dec. 2018 at Sunway University, with the first author.

References


Affective role of video content in recycle learning

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Abstract: In this paper, we describe the affective role of multimedia learning, specifically on video as a medium to tell the stories for recycling awareness. Recycling has become an important agenda in today's society and addressing the awareness of recycling has become critically important in education. Affective learning is one of the ways to achieve learning motivation, intention and therefore action for recycling. Using Video as a communication tool to motivate the learners is considered as a way of learning interaction. Therefore, video design with affective intention in mind can be an effective way to foster awareness and subsequently learning. This paper intends to explain the processes and content used for creating a recycling workshop promotional video that potentially evoke the affective domain of the young learners between 15 – 30 years old, in a storytelling kind of progression. This video will serve as a platform of communication with the audience about the importance and impact of plastic pollution. Future directions of research on this project is to create more such videos for recycling awareness and actions.

Keywords: Affective learning, recycling, video, Adobe Premiere Pro

1. Introduction

In this digital age, affective learning can be destined through the use of digital video and its technologies. Affective learning revolves around emotions, feelings and learning. Affective learning domain as one of the three main domains of learning from Bloom's taxonomy of knowledge. Affective domain links to feelings, value, attitudes and motivations of learners (Sha & Hong, 2017; Belanger & Jordan, 2000; Krathwohl, Bloom, & Masia, 1964). Rosalind (2000) defined emotion as an art, entertainment and certain social interaction that is not limited to itself, but also acts as a motivator to influence perception. Digital media computing can be an effective supportive and widely available tool (with its methods) for creating digital media content such as video. With emotional treatment in mind, video is currently the modern and important communicative and learning tool (Giannakos, Chorianopoulos, Ronchetti, Szegedi, & Teasley, 2014). Video is a part of multimedia and it is the medium to transfer knowledge as well as information. It is considered as a very convenient way to learn with the assistant of visual, motion, audio and graphics. To trigger the learners’ affective domain, it is important to implement the emotion or affective design elements into video creations.

The purposes of this paper are two-fold: 1) To explain how a video design based on affective learning is created for instilling awareness on recycling to the audience, 2) How is the sentiment of audience after viewing the video on their own in recycling? This paper is arranged with the first section explains the importance of video for affective learning domain, it then explains an example of the processes of creating an affective oriented video content and finally presents a simple analysis of sentiment or emotion of audience towards the video.

2. Video and Affective Learning Domain

Online videos have become popular due to the easy access and immersive content that attracts the audience. YouTube, the largest video-sharing site has 2 billion monthly viewers worldwide as of May
This number is still growing and it is more influential than traditional TV or other online content creation platforms and particularly beneficial in e-learning which relies on digital content. While video is valuable for many types of instructional events, its role in meeting educational outcomes within the affective domain of learning is compelling. Video is a powerful medium for conveying the spectrum of human emotion through the drama of the audiovisual story. Therefore, it is believed to be a faster way to instill learning and awareness among learners.

Krathwohl et al. (1964) explains that the affective domain often relates to the feeling, degree of acceptance and emotions. To associate both video and affective domain in learning, the content of the video needs to be emotional, highly and lowly arousal and valence in nature (Berger, 2011). However, video in neutral, i.e., contrast to the context of emotion will not be shared or caught attention (Eckler, 2011). Emotional effects, disgust and empathy images and videos are displayed in the video. Figure 1 shows the three screenshots of a video content designed for a workshop on recycling developed by the main author of this paper.

Figure 1. Left showing the death of the sea turtle caused by plastic waste, middle showing the landfill and right showing a sick person. (Source: depositphotos.com and mixkit.com)

The above images are shown to instill the emotional effects of empathy (death of sea turtle), disgust (landfill) and fear (sick person), which are related to the issue of learning, namely recycling awareness.

3. The Processes of Video Content Development (to be described in the workshop)

The core part of this paper will be the description and explanation of the design and development of the affective video content of a recycling workshop’s introductory video. The workshop is called Edcraft Workshop. The storytelling steps of this introductory video follow these steps: The introduction to explain the problem, the solutions that have been carried out by current researchers and practitioner, and how we provide solution through Edcraft Workshop. The key steps of creating the awareness video consist of the following:

Step1) Idea Conception.

Step2) Content gathering and script writing.

Step3) Voice-over and arrangement of audio.

Step4) Category Organization.

Step5) Final testing and checking.

Step6) Completion and export.
Following are some screenshots of processes and captured documents based on the above processes.

Step 1) Idea Conception (Figure 2)

The video duration, content and audio are written on Microsoft Whiteboard application as the video pre-work plan. From this flowchart, six topics were planned, 1) Welcome, 2) Problem, 3) Plastic, 4) Harm, 5) Solution and 6) How Edcraft solve the problem. With these 6 topics, it will be organized in a 3 to 4 minutes video.

Step 2) Content gathering and script writing (Figure 3)
Figure 3. Content research and gathering of data/information into the video script.

Based on the 6 topics, content analysis and compilation were done through different journal papers and websites. After that, sources will be compiled and documented into a script for voice over. Relevant images and videos with affective domain learning experience were gathered.

Step 3) Voice-over and arrangement of audio.

Figure 4 shows the video recording processes based on the scripts written. Simple mobile tool is used with proper recording environment without noise.

Based on the script, voice-over recording was done in 6 audio parts as shown in Figure 1.

Step 4) Category Organization.

Images, audio, videos and voice over recordings were compiled into one folder for video development. Figure 5 shows all the data created and gathered for the video production.
Figure 5. Compilation and organization of video and audio content based on different parts

Step 5) Combine, touch up, checking and refine.

Adobe Premiere Pro (Figure 6) is the main video editing software used to manage all the resources. Images and videos were imported together with music and voice over. These resources were to be processed and arranged into the storyline that we planned in Step 1.

Figure 6. Images, video and voice recording are inserted into Adobe Premiere Pro for video compilation, effects and touch up.

Step 6) Completion and Export

The completed video was exported to YouTube (Figure 7) as a platform for workshop participants to view during and after workshop.
4. Video Creation of Recycling Workshop Explained

This work is an introductory workshop video for recycling awareness. It was developed with photographs and videos captured from the waste dumping area, also from open source video stocks. This is also the first step to engage the participant to the recycling workshop.

5. Method and Sentiment Analysis

To analyse the sentiment (emotion) expressed after watching the video as developed in this study and experiencing the recycling workshop, we use the SentiStrength (Thelwall et al. 2010) classifier. Thelwall (2010) mentioned that SentiStrength is a free sentiment analysis tool that uses a lexical approach that exploits a list of sentiment-related terms and has rules to deal with standard linguistic and social web methods to express sentiment, such as emoticons, exaggerated punctuation and deliberate misspellings. This study is performing a mixed method analysis to detect the emotion strength through interview, text and scaling between negative and positive score. Moreover, this technique is capable to triangulate qualitative and quantitative methods (Rambocas, M., & Gama, J., 2013).

Four participants (A, B, C, D) who participated and experienced the workshop, watched the recycling video and created their videos during the workshop, have been invited for an interview. A list of questions was asked to them, but in this paper, only the sentiment on one interview question to be discussed. SentiStrength can manage short informal texts during the discussion, also it can evaluate texts that have been coded by humans (Kucuktunc et al., 2012, Thelwall et al., 2012).

Thelwall mentioned that the algorithm available in sentiment analysis; the result estimation can be in several forms in “binary – either positive/negative or objective/subjective; trinary – positive/neutral negative; scale – e.g., -5 (strongly negative) to 5 (strongly positive); dual scale – e.g., 1 (no positivity) – 5 (strong positivity) and -1 (no negativity) to -5 (strong negativity); and multiple – e.g., happiness (0-100), sadness (0-100), fear (0-100).” This study focuses on the trinary score to conduct between positive, neutral and negative classification.

SentiStrength can be evaluated by applying it to a set of texts that have been coded for sentiment by humans and comparing the SentiStrength scores with the human scores.

Below is the question asked to the four participants.
Question: Do you think video creation is important and how significant is video creation for you? What is important and not important?

Table 1. Sentiment detection in video on recycling using SentiStrength

<table>
<thead>
<tr>
<th>Participant</th>
<th>Answers input text of focus group discussion transcription from participants</th>
<th>Classification rationale based on word and sentence scores</th>
<th>Final Sentiment Score</th>
<th>Overall Trinary Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>I think video creation is important for the judging part, for the proof that you are doing the artwork.</td>
<td>“[sentence: 1,-1] [result: max + and - of any sentence][trinary result = 0 as pos=1 neg=-1]”</td>
<td>1 -1 0</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>some people might not know how to edit video,</td>
<td>“[sentence: 1,-1] [result: max + and - of any sentence][trinary result = 0 as pos=1 neg=-1]”</td>
<td>1 -1 0</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Contrary to what they said, yes, it is important.</td>
<td>“[sentence: 1,-2] [result: max + and - of any sentence][overall result = -1 as pos&lt;-neg]”</td>
<td>1 -1 -1</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>find correct background music for my video, then take account in time</td>
<td>“[sentence: 1,-1] [result: max + and - of any sentence][trinary result = 0 as pos=1 neg=-1]”</td>
<td>2 -1 0</td>
<td></td>
</tr>
</tbody>
</table>

The answers input text of focus group discussion transcription from participants are selected and coded based on the most suitable theme from the discussion based on the question asked. The classification rationale based on word and sentence scores uses the “dual positive – negative scales because psychological research reports positive and negative emotions can be experienced simultaneously by humans and to some extent independently” as mentioned by Norman et al (2011). In this preliminary test, the result of the classification rationale based on word and sentences score are generated directly from SentiStrength. 3 participants showed a neutral score of 0 in overall Trinary score, means the overall of the emotion is neutral from the result of the 3 participants and only one participant with overall score of -1. Emotions still require an in-depth analysis in the next stage of the study.

6. Conclusion

Through this workshop, audiences who are interested in content based (i.e. video) recycling workshops will be able to learn how an educative video with affective domain was created, from initial stage to the final stage. Also, this stage or future study allows researcher or educator to understand the emotions of
the participants with sentiment analysis. With this research data, we understand that one interview is insufficient to achieve a more concrete result, as qualitative research is to understand belief, experiences, behavior and emotions, this research is to add qualitative in emotions to the quantitative area to detect positive, negative or neutral in one’s emotion.

References


Online Collaborative Workflow for Creating Learning Videos on Mental Health

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Abstract: This paper describes an online collaborative workflow to facilitate the process of creating digital learning videos on mental health. Online collaboration allows more convenient ways for people to connect to each other anywhere and anytime. With the rapid development of technologies, online collaboration has become common and widely used for various purposes. The aims of this paper are two-fold, (1) To discuss how online collaborative workflow facilitates the overall creation processes of two digital learning videos on mental health knowledge and management and, (2) To identify key facilitative and impeding factors for a successful online collaborative workflow for creating digital learning videos on mental health. This paper presented the workflow and the findings of facilitating and impeding factors of online collaboration. Based on a qualitative data analysis of comments from collaborative members, four facilitative factors were identified as (a) individual commitment, (b) affective team support, (c) consensus and empowerment, and (d) clear instructions. There were also five impeding factors perceived by the collaborative members which are (a) lack of time, (b) challenges inherent to virtual communication, (c) technology and resource constraint, (d) lack of clear and tight guidelines, (e) lack of structured steps. Based on these findings, recommendations are provided for a more efficient online collaborative workflow to initiate group projects in online environments which is increasing in demand in the new normal era.

Keywords: Online collaborative, workflow, mental health, digital educational video

1. Introduction

Studies on online collaboration is a wide area. Many works done by some scholars such as Dillenbourg and his colleagues (Chibaudel et al., 2020 with Dillenbourg too; Haklev, Sharma, & Dillenbourg, 2018) in his research institute have evolved from the use of common technology such as online or computer-supported collaborative learning to the use of advanced technology or a more intelligent based assistance for collaboration such as collaborative MOOC research or the use of tangible interactions for visual impaired learners. Many more potential of online collaboration can be explored through technology especially in this new normal era.

The current research reported in this paper demonstrated an online collaborative workflow for digital videos creation project on mental health awareness. This fully online workflow in post Covid-19 time for the creative and rapid process of producing mental health awareness related videos may be beneficial for others.

2. Literature Review

There are advantages of online collaborative learning. A research suggested that group work tends to provide advantages to below-average students compared to when they are working alone (Nason & Woodruff, 2011). Nayan et al. (2010) mentioned that collaboration with each other towards a similar goal leads to an increase of productivity and yields better results. However, many studies are also focused on online collaborative workflows to meet some work-related outcomes. Traditional collaborative workflows have been restricted by logistical difficulties in finding space and also time to allow collaborations (Nason & Woodruff, 2011).
A project on digitization of patron requests into a new digital repository was reported by Gueguen and Hanlon (2009). The authors provided a case study based on a university’s library collaborative workflows. Also another study by Hofmann, Hollender and Fellner (2009) has done a video annotation research and presented “a reference architecture model which is based on identified phases of the video annotation workflow and proposed a larger idea of collaborative workflow by complying the basic workflow-related requirements control, task enclosure, extensibility, and information consistency.” (p. 40)

During the Covid-19 quarantine period in Malaysia, traditional collaborative workflow is almost impossible. With the rapid development of internet-based communication technologies, collaboration can now be done online which allows more convenient ways for people to connect to each other anywhere and anytime. Online collaboration has become common and widely used for various purposes. It provides an asynchronous manner of collaboration and is able to fit into everyone’s busy schedules, and other conveniences such as virtual meetings (An, Kim, & Kim, 2008). According to Nason and Woodruff (2011), online collaborative has the three characteristics, which are (1) The sharing of knowledge between the collaboration members, and act as roles of information giver or receiver; (2) Shared authority between members whereby the setting of goals within a topic is shared among the members, thereby allowing the members to approach the completion of an assignment in a manner of their choosing; (3) Collaborative learning process among members whereby members are learning from each other’s expertise (refer to Figure 1). Apart from these three characteristics, another special trait that makes the difference is the existence of the internet and communicative technologies act as a supporting element for a more effective collaboration.

Figure 1 shows an important conception of online collaboration in the technological era based on the three characteristics of online collaboration (Nason & Woodruff, 2011).

2.1 Purpose of the paper

As discussed in the previous section, there are undoubtedly some positive effects of online collaboration towards group works. However, there is still a lack of evidence to indicate if online collaborations can really help to facilitate the process of creating digital learning videos on mental health, especially in the context of Malaysian academicians (of different strengths and expertise) collaboration activities. A research states that by creating online collaborative activities in a class, it is hoped to engage the students.
in experiential learning and for a deeper insight of learning experience, but the results are not always successful, and sometimes cause new problems in the process (Armfield, 2015). Therefore this paper aims: (1) To discuss how online collaboration concepts can be implemented into the overall creation processes of two digital learning videos on mental health knowledge and management, and (2) To identify key facilitative and impeding factors for a successful online collaborative workflow for creating digital learning videos on mental health. This workshop paper presented some details of the workflow and reflection of the team on online collaboration and their learning experiences through this project.

3. Development Process of Mental Health Video Content

Two videos were created for the purpose to reach out to more Malaysian and to raise awareness on mental health. According to Hassan and Hamzah, (2018), two most common mental illnesses in Malaysia are depression and anxiety which is a major source of loss of productivity and economic development. Besides, people with mental health conditions are more likely to face other physical health problem such as HIV, TB, and other non-communicable diseases which can lead to higher mortality rate (WHO, 2019), suicidal behavior, a sense of helplessness (Kay, Li, Xiao, Nokkaew & Park, 2009). According to the National Health and Morbidity Survey in 2019, there are around 700 thousands of adults or 2.3% of the total population in Malaysia are facing mental health challenges, which implies the seriousness of rising trends of mental health issues in Malaysia. Therefore, there is a pressing need for some medium to raise awareness on mental health and to educate Malaysian on how to safeguard their own mental health.

This section focuses on the online collaboration for the development process of mental health video during the covid-19 pandemic to raise awareness on mental health, and as an educational video providing guide for the workers at home to be more aware of their mental health during the period of lockdown.

The team is made up of three psychology academic experts who are responsible for providing contents for the video. Two video editors to compile all the contents and produce the video. A visual and art designer responsible to improve the design and presentation of content in the video. Lastly, a team leader responsible to coordinate and oversee the whole video creation process. The conception of online collaboration which was discussed previously is implemented in defining the video creation process. The concept helps to identify which process is essential to be included into the video creation process.

The tasks that are defined from the concept of online collaboration are later arranged based on the three stages of learning phases by Jonassen, as he suggested engaging learners in activities that help them to analyze and explore the problem situation, articulate their solution and then reflect on the outcomes and their experiences can help promote collaborative learning among learners (Bennett, 2011). Another recent research also apply Jonassen’s learning phases to design web-based collaborative learning (Leow & Neo, 2018). Figure 2 shows the online collaborative workflow for creating learning videos on mental health which was developed based on the conception of online collaboration (Nason & Woodruff, 2011) and the three stages of learning phases by Jonassen (Bennett, 2011).
Figure 2. Online collaborative workflow for creating learning videos on mental health.

The following are some screenshots of processes and captured documents based on the above processes.

Step 1) Proposal, task delegation, scheduling and documentation (Figure 3)

Figure 3a. Proposal, task delegation, scheduling and documentation
Project proposal was planned and written with objectives, steps, team members’ role and Gantt chart. After showing the proposal to the team members, a weekly Google Meet meeting was carried out to discuss the process of the digital content development. Each video was expected to be completed in one month.

Step 2) Video content collection and recording from psychology experts.

Figure 4 shows a snapshot of the scripts prepared by the experts for their initial thoughts of contents to be presented in the video. Both experts discussed their scope to avoid overlap of contents. A few revisions on the script were done before confirming the final scripts. It was an iterative process where creative words and effects were added into the scripts for later development.

Scripts from psychology experts/lecturers are a guidance for storyboarding and video editor to insert the correct term for subtitle. Chung (2006) mentioned that the term of working script was specifically as a guidance for minor changes before recording for voice overs for the stories of the videos, so the psychology experts/lecturers are guided by the scripts during the video developmental stage later. Moreover, a working script as in Figure 4 was necessary for structuring and visualizing a multimedia digital story into a storyboard format.

Step 3) Storyboarding.

Storyboarding is a process to visualize a movie, animation, or digital story. It is also a sketch or blueprint for multimedia digital story. Besides, storyboarding involves the incorporation of media components, the interaction with the audience, planning the sequence of scenes, transitions, and special effects (Chung, 2006). Storyboard is based on the information collected from the psychology expert and it is very important to express to the video content editor before video recording. It is a guide with a timeline in each frame of the storyboard. On the left on figure 6, it is a 6 x 3 tile storyboard, whereas on the right
is a 5 x 3 tile storyboard. Both are fitted in an A4 size dimension in horizontal.

For the first video, on the left from figure 5 shows that there are 6 main sections to be showing to the audience, each section is represented by one alphabet from P, E, R, M, A, H. The video starts with the psychology expert explaining the PERMAH model and facts that create mindfulness. P is the positive emotion that guides the audience on how they can appreciate their life, E, for Engagement, this is how they can be calm and always in the “flow” whenever they are working. R, for relationships, in the video showing a pair of happy couples having a conversation. M, for meaning, this is to guide the audience to spend some time to think about the meaning of their actions and planning. A for accomplishment, video shows a team with happy faces after achieving their goals. Finally, H is health, which shows someone exercises to maintain their health performance.

For the second video, on the right of figure 5. The psychology experts describe the flow of the story in 4 main categories, which are type A, type B, introvert and extrovert. Psychology experts explain each type of worker with different phenomena. In the video, type A has a strong character, whereas type B needs type A to be more productive. However, for extrovert, they are more outgoing and introverts are the opposite of extrovert.

Step 4) Video recording.
Two Psychology experts / lecturers from their respective institutions recorded and shared their raw video and audio files with the team.

Step 5) Mental health media content categorization and organization.
Images, audio, videos and voice over recordings were compiled into one folder for the next step on video editing and development.

Step 6) Video compilation and editing.
Videos were arranged properly to get the result as expected in the storyboard. In order to effectively express the storytelling of both videos, the weekly meeting feedback improves the contents presentation.
Step 7) Moderations and touch up.
The team of the project will moderate the video to check the utilization of time and quality of the information after the video has been compiled and released as the first version. Whenever there is a new version, a new number will be assigned to the source file as the version, for example, permah(v2).mp4 or personality(v3).mp4. There are up to 9 revisions throughout each of the video processes. Revisions including, color of text, background, use of time, suitability of images. With the final version ready, the video was exported to a video sharing platform, namely YouTube.

Step 8) Team members’ reflection and observation.
Last step of the video creation process is a data collection and will be discussed in more detail (in Section 3). Basically, team members were requested to provide their experience and review of the project in order to understand their perceptions, experience and their thoughts regarding the creation project. These words of reflection were written down and were further extracted as presented in Table 1 and Table 2 (in Section 4).

4. Online collaborative workflow explained
This part discusses the implementation of online collaboration in creating two educational videos to raise awareness on mental health among Malaysians and to guide them how to safeguard their own mental health. The videos were developed with the collaborations between psychology experts and video creation experts from 2 different organizations in Malaysia, namely Multimedia University (MMU) and International Medical University (IMU). Psychology experts provided their contents such as photographs and videos and messages/information to be included in the video. The video expert was responsible to do the compilation of all the contents provided by the psychology experts. At the beginning of this project coincidentally met with the urgent announcement of the Movement Control Order due to a sudden spike of COVID-19 outbreak in Malaysia. This has forced the team to work virtually. The team members were able to collaborate virtually and work closely mediated by online communicative technologies such as Google Meet, WhatsApp and Google Drive. Asynchronous
manner of collaborative workflow was applied because it is effective in enabling different members of the group to work together despite each of them having different schedules. For this purpose, a WhatsApp group application was used. Some members uploaded information / video files that they wanted to share with the team into Google Drive, and all members provide their views on the videos at their own convenience. This increases efficiency in getting the work to be viewed and commented for improvement. It was also time saving and resource saving (no travelling needed) as everyone can have a meeting virtually at their own convenience.

However, many issues arise during the process, such as miscommunication and thus causing unnecessary mistakes and eventually delay the completion of the project. The facilitative and impeding factors as perceived by the team members during the overall video creation process will be discussed in the next section. These findings enable a better understanding of online collaboration for video creation, by identifying impeding factors and key facilitating factors. This paper will serve as a guide for anyone who wishes to implement online collaborative workflow in their projects, they will know what to do and what to avoid and ensure higher productivity and effectiveness.

4.1 Data collection

All seven members involved in the video creation were requested to provide their feedback after completing the video project. Their feedback was collected in order to better understand their perceptions regarding online collaboration for video creation. The members were asked to comment on the factors they perceived as important that facilitated the completion, and the factors believed to have prevented the completion of the online collaborative work. The two questions are adapted from a previous study as below (An, Kim, & Kim, 2008):
1) List the factors of the overall online collaboration workflow, if any that led to the successful completion of the video creation.
2) List the factors of overall online collaboration workflow, if any that impeded the successful completion of the video creation.

4.2 Data analysis

There were two coding schemes namely Facilitative and Impeding Factors, which were used to categorize the feedback. The Facilitative Factors Coding Scheme consisted of five major categories, while the Impeding Factors Coding Scheme consisted of seven major categories (An, Kim, & Kim, 2008). Table 1 and 2 act as an analysis table for the thematic codes with main codes and elaborations of codes. As for this present study, simple coding tables are presented in these tables.

The analysis of the feedback from the team members occurred at different phases. First, two coders segmented all the keywords in the feedback using the coding schemes (Segmenting stage) which served as a preliminary data set. Following the preliminary segmentation, discrepancies were resolved through discussion. The two coders (the main and co-author of this paper) then individually coded the segmented units based on the coding schemes (Coding stage). In the last stage, discrepancies were again resolved by discussion between the main and co-author of this paper. The comments which are coded into respective categories are more distinguishable and more defined for better understanding of the perceptions towards online collaboration. It is hoped that the results allow the realization of improvement for a more effective and seamless online collaborative workflow for creation of digital learning videos on mental health.

Table 1 includes major categories under Facilitative Factors which were developed through an iterative process by identifying themes based on comments from the members.
Table 1. Perceived Facilitative Factors

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual commitment to create learning video</td>
<td>• Meeting the necessary due dates (weekly on Thursday) • Completing the assigned work • Participation /feedback (all members provide their feedback respectively)</td>
</tr>
<tr>
<td>Affective team support radiates a positive vibe</td>
<td>• Members provided positive remarks and encouragement. • Continue learning attitude and willing to take challenges.</td>
</tr>
<tr>
<td>Consensus and empowerment given to the respective roles</td>
<td>• For example, the overall video artefact conception and sections were given the empowerment to the video editor to decide.</td>
</tr>
<tr>
<td></td>
<td>• The mental health contents were given the experts to decide what is best.</td>
</tr>
<tr>
<td>Some clear instructions were in place; brainstorming could produce a</td>
<td>better title / visual for the project.</td>
</tr>
</tbody>
</table>

Table 2 includes major categories under Impeding Factors which were developed through an iterative process by identifying themes based on comments from the members.

Table 2. Perceived Impeding Factors

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of individual time to allocate for the project - to commit to these extra tasks due to time demand for other priority duties</td>
<td>• Not meeting the necessary due dates • Not completing the assigned work on time • Lack of participation / feedback (idle time with no feedback at times)</td>
</tr>
<tr>
<td>Challenges inherent to virtual communication</td>
<td>• Problem faced when discussing during virtual meetings, or when sharing information through online communication technologies. A few members' internet connection was poor and frequently disconnected.</td>
</tr>
<tr>
<td></td>
<td>• Requires a more advanced / fast technology for better audio-visual quality and speed on editing the videos.</td>
</tr>
<tr>
<td></td>
<td>• No recording studio facilities; all via home setup and to do it during nighttime (quiet time)</td>
</tr>
<tr>
<td></td>
<td>• Limited resources resulted in using stock photos and videos, open source music, etc.</td>
</tr>
<tr>
<td></td>
<td>• Tedious of the final stage to refine the videos; many rounds were required.</td>
</tr>
<tr>
<td>More tighten, clearer and communicative instructions should be</td>
<td>established:</td>
</tr>
<tr>
<td></td>
<td>• Unclear guidelines such as process flow for the video creations • To avoid redo, and to produce a better design for the visual part of the videos.</td>
</tr>
<tr>
<td>Lack of structured steps to adhere to a better process of workflow.</td>
<td>• Some unclear steps were observed during the process.</td>
</tr>
</tbody>
</table>

5. Conclusion and future research

Online collaboration workflow can be an effective method to facilitate the creation of digital video on mental health. By using the internet and other communication technologies, it is an effective means for facilitating collaborative processes such as meetings, sharing of information, sharing of work progress, and giving feedback. Online collaboration is simply a more convenient and flexible means for a successful collaboration. Yet, despite all the benefits of online collaboration, there should be some realizations for a successful collaboration to happen; a meaningful online collaboration will not happen if the team is not synchronized properly. Besides, there should also be a realization that some attributes of online collaboration such as asynchronous communication may cause different problems that might not surface during face-to-face group work. Therefore, it is necessary to consider the key Facilitating
Factors and Impeding Factors, and re-conceptualize an improved online workflow (particularly for digital video creations) that fits a certain context to ensure a successful online collaboration process, especially in considering those factors surfaced in this study. Hopefully this paper will serve as a guide for those who wish to implement an effective and successful online collaborative workflow in their project. Future research is to apply the findings from this paper to create a well-structured and effective online collaborative workflow to collaborate with other organizations to create more mental health related contents. A more proper qualitative data analysis method to be used for analyzing users or creators’ feedback on their usage experiences on online video for their improvements of mental health.

References


Estimating Student Learning Ability from Massive Open Online Courses

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\textsuperscript{c}School of Knowledge Science, Japan Advanced Institute of Science and Technology, Japan
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Abstract: Massive open online courses (MOOC) provide a possible way for students to learn knowledge by themselves. Since the number of enrollments for each course is much larger than traditional in-person courses, it is hard for teaching faculty to master the learning ability of each student. However, estimating student learning ability is of great importance for delivering course content. Towards this goal, in this paper, we provide a novel way to estimate personalized learning ability for each student from their answering records in an exam by applying machine learning techniques, called truth discovery, which can automatically estimate a weight for each student and infer answers of questions. The weight can be considered as the student learning ability. The experimental results demonstrate the effectiveness of the utilized truth discovery approach for estimating student learning ability.

Keywords: Student learning ability, massive open online courses, truth discovery

1. Introduction

With the rapid development of science and technologies, more and more people want to seek the cutting-edge knowledge from massive open online courses (MOOC) and learn the knowledge by themselves. This is a new resolution compared with traditional in-person courses. In traditional courses, faculty can adjust the teaching speed and content based on the reaction of students. On the other hand, since the number of students is small, faculty is able to master the learning ability of each student accurately. However, for online courses, it is hard to estimate the learning ability for each student as the number of enrollments is much larger than traditional classes (Hwang et al., 2017, Yin et al., 2017; Yin et al., 2015).

However, estimating student learning ability is of great importance for delivering course content. If students master all the content, then teaching faculty may introduce more advanced knowledge to enhance the quality of the course. Otherwise, teaching faculty may introduce more details and provide more examples to help students understand the course content well. Thus, how to design a new approach to automatically estimate student learning ability is a key challenging task in massive open online courses.

Existing work on student learning ability estimation mainly focuses on supervised learning (Lincke et al., 2019a; Lincke et al., 2019b; Wang et al., 2019). These approaches use machine learning and data mining methods to learn student learning ability based on the answering history data. For each question in the training data, the ground truth data are available. However, for online courses, especially for the essay questions, it is hard to obtain the ground truth data. In this scenario, supervised machine learning approaches cannot work. Thus, the new challenge is how to estimate student learning ability even without using ground truth data.

To address this challenge, in this paper, we provide a novel way to estimate personalized learning ability for each student from their answering records in an exam by applying state-of-the-art machine learning techniques, called truth discovery, which can automatically estimate a weight for each student and infer answers of questions (Li, et al., 2014; Ma et al., 2015; Xiao et al., 2016, Wang, et al., 2017, Zhang et al., 2016, Ma, et al., 2017; Zhang, et al., 2018; Yao, et al., 2018). The weight...
can be considered as the student learning ability. We conduct experiments on an exam dataset collected from an online Japanese course at Dalian University of Technology. The experimental results demonstrate the effectiveness of the utilized truth discovery approach for estimating student learning ability.

2. Exam Data Analysis

The Exam dataset contains 43 questions, 199 students, and 8,544 answering records. Each question has four choices but only one correct answer. We provide distributions of student answers on three questions with different difficulty levels in Figure 1. The red bar represents the number of the students who provided the correct answers.

![Figure 1. Examples of questions with different difficulty levels.](image)

In Figure 1, Question 11 is easy, and 97.0% students can answer it correctly. However, for Question 43, only 31.2% students can provide the correct answers. Therefore, this is a hard question. Intuitively, if students always answer correctly on hard questions, the learning ability should be higher than others, i.e., the answers provided by these students are more reliable. In other words, the more reliable a student is, the more likely this student would provide trustworthy answers, and vice versa. This principle is in accord with the idea of truth discovery approaches.

3. Truth Discovery

The goal of truth discovery approaches is to learn a weight for each crowd worker and estimate the true answer for each question or task. In our scenario, the weight of each crowd worker can be considered as the learning ability of each student, and we apply a commonly-used truth discovery model, called CRH (Li, et al., 2014), to estimate the learning ability.

Let $N$ represent the number of students and $M$ denote the number of questions. The answering record provided by the $n$-th student on the $m$-th question is denoted as $a_{nm}^m$. The goal of this task is to estimate the learning ability $w_n$ for the $n$-th student and infer the true answer $t_m$ for the $m$-th question following the above-mentioned principle, which can be mathematically defined as follows:

$$\min_{T,W} \sum_{n=1}^{N} \sum_{m=1}^{M} w_n d(a_{nm}^m, t_m) \quad s.t. \sum_{n=1}^{N} \exp(-w_n) = 1,$$

where $T$ is the set of inferred answers, $W$ is the set of estimated learning ability of all the students, and $d(\cdot, \cdot)$ is the distance function. In this paper, we use 0-1 loss as the distance function, i.e., if the answer provided by a student is the same as the estimated truth, the loss is 0; otherwise, the loss is 1. The loss function is formally defined as follows:

$$d(a_{nm}^m, t_m) = \begin{cases} 1 & \text{if } a_{nm}^m \neq t_m \\ 0 & \text{otherwise} \end{cases}$$

We can apply iterative procedures to solve the above optimization problem as (Li, et al., 2014). First, we use majority voting approach to infer the true answers for questions. We then fix these answers
to learn the learning ability of students using \( w_n = -\log \frac{\sum_{m=1}^{M} d(a^m_n, t_m)}{\sum_{n=1}^{N} \sum_{m=1}^{M} d(a^m_n, t_m)} \), and in turn, we fix the learning ability to estimate the true answers, i.e., \( t_m \leftarrow \arg\min_{t_m} \sum_{n=1}^{N} w_n d(a^m_n, t_m) \). These two steps are iteratively updated until these two parameters converge.

4. Experiments

We use error rate as the evaluation metric, which is defined as the number of incorrect estimated questions divided by the total number of questions \( M \), to evaluate the proposed approach for estimating student learning ability. The lower the error rate, the better the performance. We use majority voting (MV), TruthFinder (Yin et al., 2008), and Investment (Pasternack et al., 2010) as baselines, and the results are listed in Table 1. We can observe that the applied CRH can achieve the best performance, which illustrates the effectiveness of the used approach.

<table>
<thead>
<tr>
<th>Method</th>
<th>Error Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>MV</td>
<td>0.1163</td>
</tr>
<tr>
<td>TruthFinder</td>
<td>0.2326</td>
</tr>
<tr>
<td>Investment</td>
<td>0.2326</td>
</tr>
<tr>
<td>CRH</td>
<td>0.0698</td>
</tr>
</tbody>
</table>

Besides, to validate the reasonability of applying CRH framework, we conduct the following experiment. For this exam, the lecturer assigned scores for each question, and the full scores are 100 points. We plot the comparison graph between the real scores and the estimated student learning ability in Figure 2. We can observe that the learned ability values (Y-axis) are positively correlated to the final scores given by the lecturer (X-axis), which clearly shows that the estimated weights by the CRH framework are reasonable and accurate to reflect the learning ability of students.

5. Conclusions

In this paper, we investigate a new machine learning approach to estimate student learning ability. Through analyzing the results in a real online Japanese course exam, we validate the effectiveness and reasonableness of the applied approach. In the future, we aim to design more advanced and novel approaches for estimating student learning ability.
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References
Research trend and development process in learning analytics: a review of publications in selected journals from 2008 to 2019

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Abstract: We employed a Co-citation analysis by the Citespace software for the trend and development process in learning analytics. Through the clustering term time-zone view, it is clearly shown that 15 research clustering terms occurred from 2008 to 2019. Moreover, this paper proposed a clear review when these terms emerged and how they grew.

Keywords: Co-citation, Learning Analytics, Literature review

1. Introduction

With the development of technology, learning analytics (LA) have been improved (Yin & Hwang, 2018; Yin, Yamada, & Shimada, 2019). To better understand the development line of learning analytics, many researchers proposed literature reviews with different perspectives. For example, states, trends (Dawson, Gašević, & Siemens, et al., 2014), factors, nature, fundamentals, applications (Peña-Ayala, 2018), limitations, methods, and key stakeholders (Leitner, Khallil, & Ebner, 2017). Although there was evidence of how many research terms occurred, it is not a clear outline of when they emerged and how they grew.

2. Method

2.1 Data

14,035 records were gained on the Web of Science, by keywords: “learning analytics” or “education data mining” and timespan: 2008 to 2019. Then, from 14,035 records, selecting papers published in the top 20 publications by Google Scholar Metrics, and finally we got 496.

2.2 Analysis Method

Clustering in data mining is a process of aggregating and classifying data in complex networks based on similarities. In keyword clustering analysis, clustering reflects the similarity of nodes in a network (Chen, C. et al., 2010), which is helpful for identifying and detecting representative knowledge subgroups in a research field, i.e., hot topics in the research field. By setting the network nodes as “Keyword” in the Citespace software, and clustering them on the basis of keyword co-citation network. Finally, a keyword clustering network by time-zone is obtained, as shown in figure 1. The figure body is the historical development lines, which represent the trend of each clustered term. The label on the left is each clustering term name. The number on each line represents the order of each node.
3. Results

![Figure 1. Keyword co-citation network clustering time-zone (Top 10).](image)

In the past decade, the clustering term of LA includes 15 clustered terms, rule-based indicator definition tool, final grade, objective perspective, early warning system, data analysis, collaborative problem-solving activities, software suite, open distance learning, assessment activity, students’ behavior mining, institutional strategical plan, managing cognitive load, emerging educational technologies, understanding social interaction, practical application. I selected the top 10 clustering terms for analysis.

3.1 Rule-based indicator definition tool

“Actionable insights” merged in 2014. There have been two concentrated development stages. The first one consisted of “data collection” “learning context” and “self-regulated learning” within 2015. The second one included “multimodal data” “machine learning” and “student performance” within 2017. “Neural network” “case study” and “digital learning environment” are the latest research nodes.

3.2 Final grade

It has an even development line, starting with “combing education data mining” in 2011. “Considerable variability” “learning management system” “adult learners time management” “previous research” “learning analytics technique” “data source” “educational research” “5-year development” “open educational resources” and “google analytics” sequentially emerged from 2011 to 2016. Concentrated research has been formed by “applying learning analytics” and “undergraduate students” in 2017. “Course structure” became the latest research node in 2019.

3.3 Objective perspective

It started from 2008 to 2016. A concentrated development stage exited in 2015, including “learning behaviors” “educational technology” and “learning environment”. It ended with “3D virtual laboratory” (2016) and “preliminary finding” (2016).

3.4 Early warning system

The initial point of this term concentrated with the “early warning system” “3at-risk students” and
“education institutions”. After that, the second concentrated development stages followed by “earning analytics tool” “teacher inquiry” and “learning design”. Since 2014, this term has begun to enter an even stage, the “knowledge gap” “educational institutions” “pedagogical model” “social network” “early identification” and “course materials” have emerged and developed in succession until 2017. From then, “blended learning” has been gained attention by 2019.

3.5 Data analysis

“Social learning” and “social network analysis” became the initial nodes in 2013. In the next three years, “massive open online course” “learning performance” “early detection” “foreign language” and “online environment” sequentially entered into the field of data analysis. The concentrated development stage occurred within 2017, focusing on “learning strategy” “online learning” “learning analytics dashboards” and “student engagement”. In the past two years, it shifted to “demographic characteristic” “effective strategy” and “decision tree”.

3.6 Collaborative problem-solving activities


3.7 Software suite

There were 7 research nodes in it, which presented in a way that is widely spaced over time. The first node was “educational context” in 2008. The second concentrated development stage consisted of “competence acquisition” “blended courses” and “course design” in 2012. The fifth node was “educational data”. Both “students’ behavior” and “empirical evidence” together constituted a research node in 2018. It followed that the predictive model became the latest research node in 2019.

3.8 Open distance learning

“Content analysis” was the starting point in 2009. After that, some research nodes continued to emerge until 2015, such as “authoring system subject” “critical reflection” “blog content” “analyzing large dataflows” “conceptual framework” “student data” “analytic approach” and “big data”. There were two concentrated development stages before 2015, including “ethical considerations” “emerging field” and “learning analytics system”. From 2017 to 2019, “classroom settings” “systematic review” “entire course” and “data science” sequentially emerged and formed the fourth concentrated development stage.

3.9 Assessment activity

There were 4 obvious development stages. The first one was composed of “complex chemical system” “conceptual understanding” and “complex system” in 2010. “Assessment activity” “supporting teachers” and “clustering analysis” sequentially emerged and constituted to be the second one in 2013. Compare with the former two stages, “learning experience” was the third one. From 2017 to 2019, “process mining” “course completion” “massive open online course” “available tool” and “theoretical framework” formed the fourth one.

3.10 Students behavior mining

The earliest emergence of this term was “communication technology”, following by “learning activity”
in 2011. From 2014 to 2016, the increasing number has been accelerated. For example, “90th percentile” “final course grades” “learning outcome” “disciplinary factor” “learning designs” “virtual learning environment” “student-facing learning analytics” and “control group”. The latest research nodes were “learning approach” “students’ engagement” and “e-learning environment” since 2017.

4. Conclusion

This study found that some terms have been persistent from 2008 to 2019, in which some nodes merged in a concentrated or separated way. For example, “collaborative problem-solving activities” and “software suite”. In addition, the majority of terms presented a shorter development line, and grown from a certain time to the present. Such as “rule-based indicator definition tool” “final grade” “early warning system” “data analysis” “open distance learning” “assessment activity” and “students behavior mining”. It is worth noting that “objective perspective” have continued to develop since they appeared, but they have not received attention in recent years.

References


Co-Creation of Structure Visualization with Virtual Reality in On-Line Communities: An Analysis of Student Engagement

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Abstract: This study investigated student engagement in paper-based, digital 2D, and VR co-creation environments. The study utilized a quasi-experimental research design with 66 tenth-grade students in two EFL classes in northern Taiwan. The results showed insignificance of co-creation platforms for behavioral and cognitive engagement. However, VR co-creativity resulted in significance in emotional engagement, due to its novel and immersive nature. The study suggested that co-creation be a long-term project for thorough idea synthesis lest the essence and strength of co-creation be under-estimated.

Keywords: Co-Creation, Virtual Reality, Student Engagement

1. Introduction

Virtual reality (VR), with presence, interactivity, and immersion (Ryan, 2015), has proved value in conceptualizing abstract environments (Lamb, 2014), activating cognitive attributes (Lamb, 2014), and improving retention and efficacy for novel information (Freina & Ott, 2015). For social constructivists, VR creation could further turn traditional drill-driven instruction into contextualized inquiry learning where authentic contexts stimulate situativity in knowledge development.

VR co-creation, distinguished from collaboration in high equity and shared leadership for collective wisdom, has shown positive outcomes in subject-matter comprehension (Bertolini et al., 2018), increased self-awareness (Lubicz-Nawrocka, 2018), and improved collaborative skills (Blau & Shamir-Inbal, 2017). Moreover, it has sparked a reading pedagogical shift where student engagement is featured (Rapp et al., 2007).

Student engagement, referring to learners’ physical or mental participation for expected academic outcomes (Sun & Rueda, 2012), is specified as behavioral, emotional, and cognitive, each encompassing diversified activity involvement, emotional responses, and psychological efforts in learning (Fredricks, Blumenfeld, & Paris, 2004).

Student engagement helps learners to be goal-oriented, which in turn increases their chance for learning success (Bakker et al., 2015). However, to date, little research has investigated student engagement in VR co-creativity. To fill in the gap, this study explored the effects of on-line real-time VR co-creation on student engagement for creative structure visualization in EFL classrooms. The research model of this study is shown in Figure 1.
2 Materials and Methods

2.1 Participants

This quasi-experimental research was conducted in 2020 and involved one teacher and 66 tenth-grade students in two English classes from a public senior high school in northern Taiwan. To assess the effects of the paper-based, digital 2D, and VR platforms, the classes were divided into Control Group, Experimental Group A, and Experimental Group B, with a valid sample of N= 22 for each.

2.2 Methods and Instructional Design

The experimental process is shown in Figure 3. Session 1 involved the pre-test on student engagement and reading strategy training. Session 2 involved genre reading instruction: text-based and numerical reports. To visualize the global reading structure, Control Group performed paper-based co-creation, while Experimental Group A and B respectively used Google Jamboard and CoSpaces for digital 2D and VR co-creation (See Figure 2). The experiment ended in Session 3 with the post-test on student engagement.

![Figure 2. Co-Creation Interfaces of the Various Groups.](image-url)
2.3 Instruments

The student engagement scale, based on Fredricks, Blumenfeld, Friedel, and Paris (2005), with reference to that of Sun (2014), was a 6-point Likert scale with five questions for behavioral, six for emotional, and eight for cognitive engagement. In terms of reliability of the post-test scores, the Cronbach’s alpha value for the scale was .91, while the reliability of the constructs had scores of .55–.93, indicating an acceptable to excellent overall internal consistency (George & Mallery, 2003).

2.4 Digital Co-Creation Platforms: Google Jamboard and CoSpaces

In this study, Google Jamboard presented digital 2D structure visualization, whereas CoSpaces enabled learners to co-create immersive scenarios that could be explored virtually using cardboard headsets. Both allow real-time co-creation. Coding within CoSpaces stimulates creativity for turning abstract to concrete by programming objects to follow instructions.

3 Results and Discussion

Analysis of covariance (ANCOVA) in SPSS 20 was performed on the post-test for student engagement to identify between-group differences, with the pre-test as the covariant, the post-test as the dependent variable, and the co-creation mode as the fixed factor. For student engagement, the effect of interaction between the covariates and variables was not significant (F=2.57, p= .086), nor was the homogeneity hypothesis test result for intra-group variance.
Table 1. Summary of Covariance Analysis for Student Engagement

<table>
<thead>
<tr>
<th>Source of variance</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
<th>Partial $\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariates</td>
<td>.899</td>
<td>1</td>
<td>.899</td>
<td>2.74</td>
<td>.10</td>
<td>4.5%</td>
</tr>
<tr>
<td>Inter-group</td>
<td>1.54</td>
<td>2</td>
<td>.77</td>
<td>2.35</td>
<td>.11</td>
<td>7.5%</td>
</tr>
<tr>
<td>Intra-group</td>
<td>19.01</td>
<td>58</td>
<td>.33</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>21.60</td>
<td>61</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As shown in Table 1, the overall student engagement revealed no significant differences among the co-creation platforms. Specifically, the covariate failed to significantly predict the dependent variable ($F=2.74$, $p=.10$), suggesting the post-test on student engagement was not influenced by the pre-test. Moreover, with the pre-test effect removed, the effect of the co-creation mode was not significant ($F=2.35$, $p=.11$), connoting the insignificance of the co-creation platforms on the post-test.

Further ANCOVA results on the three constructs were reported in Table 2. The effect of the co-creation mode was insignificant in behavioral engagement ($F=1.01$, $p=.32$) and in cognitive engagement ($F=.29$, $p=.75$); the post-tests on the two constructs were not influenced by the co-creation platforms. However, emotional engagement was greatly affected by the co-creation mode ($F=6.25$, $p=.003$). Specifically, VR CoSpaces was the most influential, followed by the Jamboard and paper-based co-creation environments respectively.

Table 2. Summary of Covariance Analysis for the Constructs of Student Engagement

<table>
<thead>
<tr>
<th>Constructs</th>
<th>$F$</th>
<th>$p$</th>
<th>Post-hoc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavioral engagement</td>
<td>1.01</td>
<td>.32</td>
<td></td>
</tr>
<tr>
<td>Emotional engagement</td>
<td>6.25</td>
<td>.003</td>
<td>(3) &gt; (2)</td>
</tr>
<tr>
<td>Cognitive engagement</td>
<td>.29</td>
<td>.75</td>
<td>(2) &gt; (1)</td>
</tr>
</tbody>
</table>

Note. (1) = Control Group; (2) = Experimental Group A; (3) = Experimental Group B

Insufficient co-creation time might account for insignificance in the behavioral and cognitive constructs. As Jensen (2008) proposed in brain-based learning, the development of cognitive attributes and preferred learning modality takes considerable time. Contrarily, emotional responses would be more easily aroused especially in VR owing to its novel, immersive, and experiential nature.

4 Conclusion and Implications

The study investigated student engagement in online real-time VR co-creativity in EFL classrooms. Based on the ANCOVA results, the effect of the co-creation platforms was not significant on behavioral and cognitive engagement. However, emotional engagement was significantly influenced by the co-creation spaces, among which VR CoSpaces was most emotionally engaging.

The study suggested that VR co-creation for collective intelligence be a semester-long project, instead of a short-term activity for transient effects, lest co-creators fail to reach consensus and the strength of co-creation tools be under-estimated.

In conclusion, co-creation evaluation shall include both quantitative and qualitative data. Open-ended interviews and interaction logs are recommended to complement empirical analysis for comprehensive insights towards co-creation essence.
References


Study on Online Learning in Universities in the Epidemic-control Context in China

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Abstract: In December 2019, an outbreak of COVID-19 occurred in Wuhan. The State Council of China required all universities, secondary schools and primary schools to carry out online learning in an orderly manner. In order to better understand the learning effect, teaching effect, satisfaction and anxiety of teachers and students in colleges and universities during this period, this study uses questionnaires, correlation analysis and regression analysis of data to understand the current situation of online teaching and provide reference for the further integration of informatization and education and teaching.

Keywords: online learning, learning effect, teaching effect, learning anxiety

1. The Question

In December 2019, an outbreak of COVID-19 broke out in Wuhan. In order to effectively reduce the number of people gathered and prevent the further spread of the epidemic, the State Council held a press conference on January 26, 2020, requiring all universities, secondary schools and primary schools to postpone the start of the spring semester in 2020. This research through the questionnaire, correlation analysis and regression analysis of data, to understand the current situation of network teaching, provide a reference for further integration of information technology and education teaching.

2. Investigation Content

This research makes the undergraduates as the study object. A total of 12,274 valid questionnaires were received from students and 565 valid questionnaires from teachers, which were conducted anonymously.

The questionnaires of students were based on their familiarity with using the Internet platform, teachers' pre-class preparation, students' pre-class preparation and teachers' Q&A guidance. Students' online learning satisfaction were investigated as dependent variables. Teachers' questionnaires took the use of the Internet platform, teachers' teaching requirements, students' re-class preparation and students' participation in interaction as independent variables, and the effect of online teaching as dependent variables to conduct the survey.

2.1 Students' Satisfaction of Online Learning

The survey shows that students approve of the current online learning methods and arrangements. Pearson correlation test is used to test the correlation between proficiency in online platform, teachers' pre-class preparation, students' pre-class preparation, teachers' Q&A tutoring and online learning satisfaction. (See Table 1)
Table: Correlation Analysis

<table>
<thead>
<tr>
<th></th>
<th>Teachers’ Pre-class Preparation</th>
<th>Students’ Pre-class Preparation</th>
<th>Teachers’ Q&amp;A Tutoring</th>
<th>Online Learning Satisfaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skillful Use of Online Platform</td>
<td>1</td>
<td>.415**</td>
<td>.456**</td>
<td>.531**</td>
</tr>
<tr>
<td>Teachers’ Pre-class Preparation</td>
<td>.415**</td>
<td>1</td>
<td>.578**</td>
<td>.552**</td>
</tr>
<tr>
<td>Students’ Pre-class Preparation</td>
<td>.456**</td>
<td>.578**</td>
<td>1</td>
<td>.570**</td>
</tr>
<tr>
<td>Teachers’ Q&amp;A Tutoring</td>
<td>.450**</td>
<td>.677**</td>
<td>.671**</td>
<td>.575**</td>
</tr>
<tr>
<td>Online Learning Satisfaction</td>
<td>.531**</td>
<td>.552**</td>
<td>.570**</td>
<td>.575**</td>
</tr>
</tbody>
</table>

**, there is a significant correlation at the 0.1 level (bilateral)

Therefore, network learning satisfaction with other items has significant positive correlation. The correlation analysis shows that there is significant correlation, and the results are shown in the following table (Table 2). Therefore, the data means that in online learning, in addition to the factors of using the online environment of the online platform, whether students fully prepare before class affects students' satisfaction with online learning, whether teachers make adequate preparation before class and whether teachers answer questions timely also significantly affect students' satisfaction with online learning.
### Table 2: Regression Analysis

<table>
<thead>
<tr>
<th>Model</th>
<th>Nonstandardized Coefficient</th>
<th>Standard Coefficient</th>
<th>Collinear Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Standard Error</td>
<td>Trial</td>
</tr>
<tr>
<td>(constant)</td>
<td>-.529</td>
<td>.038</td>
<td>-13.991</td>
</tr>
<tr>
<td>Skillful Use of Online Platform</td>
<td>.299</td>
<td>.008</td>
<td>.273</td>
</tr>
<tr>
<td>Teachers’ Pre-class Preparation</td>
<td>.246</td>
<td>.012</td>
<td>.196</td>
</tr>
<tr>
<td>Students’ Pre-class Preparation</td>
<td>.250</td>
<td>.011</td>
<td>.214</td>
</tr>
<tr>
<td>Teachers’ Q&amp;A Tutoring</td>
<td>.208</td>
<td>.012</td>
<td>.176</td>
</tr>
</tbody>
</table>

R2=0.476, adjustment R2=0.476, F=2761.429(P<0.05)

### 2.3 Teachers’ Self-evaluation of Online Teaching Effect

All of data indicate that teachers are more willing and familiar with teaching in the same classroom with students. Pearson correlation test is used to test the correlation between the use of the network platform, teachers' teaching requirements, students' preview before class, students' participation in interaction and the effect of network teaching. (See Table 3)


Table 3 *Correlation Analysis*

<table>
<thead>
<tr>
<th>The Use of the Network Platform</th>
<th>Teacher's Teaching Requirements</th>
<th>Students' Preview</th>
<th>Students' Interaction</th>
<th>The Effect of Networking Teaching</th>
<th>The Motive of Network Teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pearson Correlation</strong></td>
<td><strong>Significance (bilateral)</strong></td>
<td><strong>Pearson Correlation</strong></td>
<td><strong>Significance (bilateral)</strong></td>
<td><strong>Pearson Correlation</strong></td>
<td><strong>Significance (bilateral)</strong></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>.164**</td>
<td>.000</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>.075</td>
<td>.178**</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>.195**</td>
<td>.203**</td>
<td>.481**</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.107*</td>
<td>.231**</td>
<td>.401**</td>
<td>.305**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.011</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
</tr>
</tbody>
</table>

**. there is a significant correlation at the 0.1 level (bilateral)
*. there is a significant correlation at the 0.05 level (bilateral)

The coefficients have passed a significant level of 5% significance test, thus the effect of teaching has significant positive correlation with the use of platform, teacher’s teaching requirements, and students’ interact. The correlation analysis shows that there is significant correlation. After the regression analysis, the results are shown in the following table (Table 4). The survey showed that teachers think that whether the network platform is skillfully used has little influence on the teaching effect.
Table 4 Regression Analysis

<table>
<thead>
<tr>
<th>Model</th>
<th>Nonstandardized coefficient</th>
<th>Standard coefficient</th>
<th>Collinear statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard error</td>
<td>Trial version</td>
<td>t</td>
</tr>
<tr>
<td>(constant)</td>
<td>.529</td>
<td>.203</td>
<td>2.608</td>
</tr>
<tr>
<td>The use of the network platform</td>
<td>.021</td>
<td>.022</td>
<td>.037</td>
</tr>
<tr>
<td>Teachers’ teaching requirements</td>
<td>.124</td>
<td>.033</td>
<td>.145</td>
</tr>
<tr>
<td>Students’ preview</td>
<td>.304</td>
<td>.042</td>
<td>.316</td>
</tr>
<tr>
<td>Students’ interaction</td>
<td>.130</td>
<td>.049</td>
<td>.117</td>
</tr>
</tbody>
</table>

R²=0.200, adjustment R²=0.194, F=34.846(P<0.05)

3. Discussion

3.1 The Inspection of Early Informatization Results

Although affected by the epidemic, the current online teaching and learning is a necessity. Up to now, although a variety of problems have appeared in the process, it is generally stable, which is a good test for the early informatization promotion.

3.2 The Good Use of Data for Teacher-student Interaction

During the epidemic prevention and control period, the core keywords of the relevant documents issued by the Ministry of Education are interaction + data. The interaction between teachers and students should be strengthened in the network teaching process.

4. Conclusion

The epidemic-control period has brought information-based teaching reform to educators in an all-round way.

4.1 The Interaction and Teaching Methods

Online teaching breaks the time and space of teacher-student interaction. Strengthening teacher-student interaction can significantly improve the teaching quality and students' learning motivation. Teachers take tasks and problems as traction to guide students to effectively use the time after class for active learning. Online teachers and students carry out high-quality discussion and communication, and feedback the learning results.

4.2 The Strengthening of Students’ Preview

The effect of students' previewing before class has a significant influence on the quality of online learning. Guide students to continue to carry forward the spirit of active learning, arrange their time reasonably, complete the preview content of the course in advance according to the teacher's
requirements, actively conduct remote interaction and communication, and feedback the learning results.

4.3 The Acceleration of Schools to Carry Out Information Management

The questionnaire shows that a common cause of online learning anxiety among teachers and students is the online teaching platform. In the later stage, the school should speed up the construction of the course platform, ensure the stable operation of online teaching, improve the platform function, and enhance the operability, simplicity and affinity of the system. In addition, the smooth development of school network teaching is inseparable from the efficient work of the management staff.

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Study on the changes of performance and learning behavior mode in asynchronous interactive learning

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Abstract: As a way of learning, asynchronous interaction has played an important role in the distance teaching. Learning performance in the process of asynchronous interaction will directly affect the learning outcomes. The process of asynchronous interaction learning activity is divided into three stages. We collect the data from the discussion board where students have asynchronous interaction in the different three stages. Social network analysis and content analysis are used for data analysis. The results indicated that the performance of learners and learning behavior mode in the asynchronous interaction were different in different stages of the course development. Teachers need to adopt specific teaching strategies according the differences.

Keywords: Asynchronous interaction, learning behavior mode, learning performance

1. Introduction

In 2019, there have been reports indicated that more than 12,500 MOOCs have been launched in China, with more than 200 million students taking them. Asynchronous interaction allows learners to have enough time to think, integrate and reconstruct knowledge system, which is considered as an effective learning activity to promote learners' online learning effect.

2. Literature review

The current research on asynchronous interaction is divided into three aspects:

1) Interaction model and structure: Chen(2004) constructs a hierarchical teaching interaction tower that progresses from operation interaction, information interaction and concept interaction, revealing how learning occurs in distance learning.

2) Interaction activity design: In the early asynchronous interaction studies, most researchers focus on the design of asynchronous interactive learning activities, which aims to promote the effectiveness of online teaching activities. In asynchronous interaction, students are both consumers and creators of learning content (Popescu, & Cioiu,2011), and knowledge is built during the interaction.

3) Interaction effect evaluation: In online learning, learners left a large amount of data on the learning platform. These large amount of information hidden in the network interaction behavior can explain the learner's behavior and even predict the learning outcome. These data represent the learner's learning status and the methods used to analyze it become the focus of researchers.

In this context, our research questions are as follows: At different stages of asynchronous interactive learning activities,

1. How does the social network structure of learners' interaction change ?
2. How does the learning behavior mode of learners change?

3. Research design

This study takes the example course, Theory and Practice of Educational Technology, a compulsory course for graduate students majoring in educational technology, which carries out asynchronous
interactive learning activities. There are 25 students. We choose three discussions from all the semester (1 from the beginning of the semester, 1 from the middle and 1 from the end). The requirements for these three topics are the same and the topics are similar. The number of discussions and the content of discussion were collected for analyzing.

4. Results

4.1 social network analysis

In this study, Gephi 0.9.2, a network analysis tool, was used to analyze data. Figure 1 and Table 1 show the results.

![Network diagrams for three periods](image)

*Figure 1. Social interaction network diagram in three periods*

<table>
<thead>
<tr>
<th>Attributes</th>
<th>First period</th>
<th>Second period</th>
<th>Third period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Node</td>
<td>22</td>
<td>22</td>
<td>23</td>
</tr>
<tr>
<td>Link</td>
<td>67</td>
<td>100</td>
<td>93</td>
</tr>
<tr>
<td>Network density</td>
<td>0.145</td>
<td>0.216</td>
<td>0.184</td>
</tr>
<tr>
<td>Modularity</td>
<td>0.309</td>
<td>0.236</td>
<td>0.252</td>
</tr>
<tr>
<td>Clustering coefficient</td>
<td>0.185</td>
<td>0.273</td>
<td>0.232</td>
</tr>
<tr>
<td>Path length</td>
<td>2.453</td>
<td>1.998</td>
<td>2.167</td>
</tr>
</tbody>
</table>

We can see that there is no obvious difference in the frequency of interaction between learners at the first period. And there is little communication between learners and only a few specific learners, so the communication scope is small and the internal structure of the social network is loose.

In the second period, the interaction frequency between learners increases obviously. Learners begin to step out of their previous communication circle and interact with learners in other communication circles. The whole social network becomes more compact internally.

At the third period, the number of communication circles formed by learners decreases, while the number of learners in the same communication circle increases. It indicates that with the development of the course, learners have formed a relatively stable circle of communication with frequent interactions within the circle, which is consistent with the previous researchers' conclusion that the time of student interaction is more in the middle of the term and less at the beginning and end of the term (Luo, & Jiang ,2008).

4.2 Content analysis

The interaction analysis model based on social constructivism developed by Gunawardena is adopted in this study. Further, another coding is added to represent the learner's non-learning behavior. The scheme is displayed in Table 2. Two researchers familiar with coding rules coded separately. After coding, the Kappa value was 0.835.
Table 2. Coding scheme

<table>
<thead>
<tr>
<th>Coding</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Sharing/Comparing of information</td>
</tr>
<tr>
<td>S2</td>
<td>The discovery and exploration of dissonance</td>
</tr>
<tr>
<td>S3</td>
<td>Negotiation of meaning/co-construction of knowledge</td>
</tr>
<tr>
<td>S4</td>
<td>Testing and modification of proposed synthesis or Co-construction</td>
</tr>
<tr>
<td>S5</td>
<td>Agreement statement(s)/applications of newly constructed meaning</td>
</tr>
<tr>
<td>S6</td>
<td>Non-related learning</td>
</tr>
</tbody>
</table>

In order to further study the interaction patterns of learners at different stages of asynchronous interactive learning, the researcher analyzed the content data using lag sequential analysis. The results are shown in Figure 2.

![Figure 2. Behavior mode](image)

In different periods of carrying out asynchronous interactive learning activities, the main types of student posts change from S1 in the first period to S3 in the second. It shows that in the first period, most students are still in the stage of disseminating their own knowledge and are not used to learning on the online platform. After half a semester of online learning, learners may have adapted to the way of online communication and learning. The connection between learners is closer. Compared with the first period, the total amount of posts is growing and the depth of the types of posts is also increasing.

5. Conclusions

This study studies the relational interactive data and content interactive data generated by the asynchronous interactive learning activities of 25 graduate students in the class of 2019 from East China Normal University. The changes of learners' learning performance and interaction patterns during the asynchronous learning process are found in online discussion. Under the background of the in-depth integration of Internet + education, the scope of online learning is expanding and the number of online learning activities is increasing. In this background, the changes in learners' learning performance in asynchronous interactive learning activities deserve researchers' attention.

The interaction pattern of learners develops more structured and hierarchy during the whole semester. On the whole, there are still some problems with learners in asynchronous interactive learning activities. Studies have shown that the presence of teachers can change the dynamic system of discussion networks. In the online teaching process, the importance of teachers has not decreased, but changed roles. The most important role of future teachers is to guide, inspire, impart knowledge, develop themselves and be role models. Teachers are transformed from the imitators of knowledge to the developers of asynchronous learning activities, and from the commanding ones to the equal constructors of knowledge with students. Therefore, in order to realize the interactive mode upgrade at each stage, teachers can conduct appropriate guidance at different stages of the course. For example, in the early stage of asynchronous interaction, learners tend to shy away from expressing their ideas in the public platform. Teachers need to pay timely attention to such students to help get to know each other quickly and adopt certain methods, such as changing the organization mode and content form etc.
6. Limitations and future work

This study has some limitations. Interactive content data encoding of this study is a way of man-made code, which is suitable for small data. With the advent of the era of big data, this way is more human cost. Future research can implement machine learning to the learners' interaction data with much data, which will have a better data support.

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“Game Playing” and “Game Making”: Gamified Applications of Topical Education

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Abstract: Through games, adults and children can practice concentration, learning abilities, analytical power, and problem-solving skills. To inspire and increase students’ learning motivations, teachers have attempted to introduce games into the classroom, but they often encounter difficulties in practical application. Many instances of game integration into lessons are reduced to “games are games, and teaching is teaching,” and student engagement disappears at the end of the game; student motivations are unable to be integrated completely with the learning goals. Furthermore, many games designed for teaching are unenjoyable and do not easily engage students. This demonstrates the difficulties of integrating knowledge with gameplay: student motivation is increased in gameplay-based learning, but it cannot be sustained through knowledge acquisition. However, in knowledge-based learning, although teaching goals are met, student motivation is not activated. Our exploration of gamified education does not simply connect games with teaching but investigates how to design appropriate game strategies based on teaching requirements to achieve learning goals. This paper focuses on topical teaching to discuss the applications of two gamified educational methods: game making and game playing.

Keywords: narrative, game playing, game making, board games

1. Introduction

Playing games is a high-level cognitive activity: animals learn required skills for survival through games. For instance, lions and tigers learn how to chase and bite each other without hurting each other when they are young; in addition to amusement, they learn hunting and other livelihood skills. Through games, adults and children can practice concentration, learning abilities, analytical power, and problem-solving skills. (E. M. Avedon & B. Sutton-Smith, 1971/2015: 325) To inspire and increase students’ learning motivations, teachers have attempted to introduce games into the classroom, but they often encounter difficulties in practical application. Many instances of game integration into lessons are reduced to “games are games, and teaching is teaching” (E. M. Avedon & B. Sutton-Smith, 1971/2015: 338), and student engagement disappears at the end of the game; student motivations are unable to be integrated completely with the learning goals. Furthermore, many games designed for teaching are unenjoyable and do not easily engage students. This demonstrates the difficulties of integrating knowledge with gameplay: student motivation is increased in gameplay-based learning, but it cannot be sustained through knowledge acquisition. However, in knowledge-based learning, although teaching goals are met, student motivation is not activated. Our exploration of gamified education does not simply connect games with teaching but investigates how to design appropriate game strategies based on teaching requirements to achieve learning goals. This paper focuses on topical teaching to discuss the applications of two gamified educational methods: game making and game playing.

2. Game Playing: Considering Topic for Discussion Through Gamified Interactions

Teaching is primarily the imparting of recognized knowledge. Analytically, this knowledge is generated and spread through narratives. Each branch of learning has a unique narrative structure and events that enable the narrative to unfold; this applies to the chemical reaction of hydrogen and oxygen in chemistry, the factors leading to the prospering of the Tang dynasty in history, or the interpretation of the basis for determining the truth in philosophy. Each event can be designed into a game. In other words, an event can be adapted into a game script; playing the game imparts an understanding of the
origin and development of the event. However, this may not be a desirable outcome of integrating games with course design. Games are not only meant for knowledge memorization. (E. M. Avedon & B. Sutton-Smith, 1971/2015: 324-325)

Fine, an American sociologist inspired by Goffman (1974), concluded that participants develop three different levels of behaviors within games. He argued that when players enter a game, they continually switch between and act within the following three “frames” (Fine, 1983: 186).

1. In an “everyday” frame (real frame), the participant performs narratives and interactions as a “(normal) person.”

2. In a gaming frame (play frame), the participant performs narratives and interactions as a “player.”

3. In a fantasy frame, the participant performs narratives and interactions as a “fantasy character.”

Mackay (2001) agreed with Fine’s perspective but argued that this observation omitted a fourth frame in which players continue the game in some form after the game ends:

4. In an aesthetic frame, the participant performs narratives and interactions as the audience (Mackay, 2001: 122).

In each frame, a person (i.e., an ordinary person, player, character, or observer) enters a different subjective state specific to the frame. This also indicates that within the game, the player has several relationships with the narrative that simultaneously change and interact, and the causalities considered by the person within different narratives differ. For instance, common people view the game as an object that is unrelated to them, but a player considers how to win the game. A character within the game script considers the direction of the character’s story, and the audience observes how the overall story develops through events as well as how the characters interact. Schema 1 lists the subjects (i.e., people) corresponding to different narrative frames and works. Games are presented in the left column, and art is presented in the right column.

| Process of subjectivation | Role as viewer | Discourse
| Subjectivity | Interrelation | Aesthetic frame
| Subjectivity | Role | Representation
| Narrative 4 | Player | Order
| Art | Play frame | Work of art
| Narrative 2 | Viewer | Knowledge
| Narrative 1 | Article | Juxtaposition
| Subjectivation at play | Game as Event | Art as Event | Subjectivation in art

Schema 1: The process of subjectivation in the event (by Jing-Li HON)

To achieve a multilevel subject perspective in a game, game mechanics and narratives must be closely integrated. Understanding and actions toward different narratives generated within this type of game interactional theory greatly surpass those when games are viewed as a fun tool for memorizing knowledge. If the interactive nature of games and the subject perspectives of different levels are ignored, the game is simply a tool for stimulating learning motivation, perpetuating one-way learning that does not shape autonomous thinking or problem-solving skills. This paper emphasizes that interaction in

11 “Fantasy frame” is the phrase in the original language, which was translated into Chinese to “advanced reality,” which refers to the imagined reality that players are engaged in. Players act according to the logic of the character they are playing in their imaginations.
games can be optimally integrated into topical teaching design. Topics, particularly public issues, include different stakeholders who interact using different narrative frames. Through games, topical teaching can avoid the dullness of recitation; furthermore, players can interact to understand the narrative context of different stakeholders and the complexity of an issue to identify a corresponding solution.

3. Game Making: Considering Topic for Discussion Through Game Design

Game design resembles artistic creation in that no unified method of design can be used. Therefore, compared with creating something from scratch, many teachers directly use existing games and modify their themes. Monopoly, for example, has been adapted frequently because of its popularity. Regarding topic-based teaching, the greatest challenge of gamification in terms of practicality is probably the integration of individual topics into games; therefore, apart from gamifying topics of learning, we developed a “game-making” logical narrative scaffolding theory\(^ {12} \) with logical thinking as its starting point. This scaffolding theory enabled students to produce topic-related games from scratch rather than adapting existing games. In addition to avoiding the pitfalls of adapting Monopoly\(^ {13} \), the scaffolding theory facilitated the design of a game that does not require prior knowledge and promotes the principle of equal treatment for all players.

The basis of the authors’ design theory is a logical structure. First, the game’s initial conditions and end goals are established. The game’s numerous paths are then organized according to the theme. To use storytelling as an analogy, the designers must first decide how the game’s protagonist begins and ends the game. They then consider what events the protagonist must experience to reach the ending. How these events are presented from the protagonist’s perspective becomes the challenge that the designer presents to the player in the game. Because the game is designed from the perspective of the player as the narrator, all actions and challenges in the game are closely linked to the game objectives to reduce inconsistencies between the narrative and the game.

The authors observed that in the classroom, students spent most of their time on the correlation between the game mechanics and the narrative instead of the design of the game system. With the teachers’ assistance and discussions, students were able to create original games that met the requirements of their stories without copied elements.

4. Conclusion

Whether through “game playing” or “game making,” teachers can determine the focus of topical discussions on the basis of their teaching requirements. If no games on the topic are available, narrative interactions of “game playing” can still be facilitated through games with similar topics. Later, when transitioning to “game making” with a clear understanding of game mechanics, participants had the opportunity to create an original game that adheres to the topic. Gamified courses not only are enjoyable but also allow students to develop autonomous thinking and problem-solving skills through “game making” as “experiential learning cycle” defined by David Kolb (Kayes, Kayes, & Kolb, 2005: 5; Kolb, 2014: 38).

\[^{12}\] "Logical narrative scaffolding theory" was developed by author Hung-Yang SHEN from his teaching experience for several years.

\[^{13}\] The problem with adapting Monopoly is that, in addition to the irrelevance of its theme and gameplay, Monopoly is often criticized for mostly involving luck and snowball effects. Furthermore, not every participant gains satisfaction from the game.
References


Explore Teaching Effectiveness of Digital Game-based Learning System in Primary School Social Field Curriculum

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Abstract: Although many scholars have proposed a digital game-based learning system and applied it to different fields, there is less emphasis on its use in the courses of social field. Therefore, this study proposed a digital game-based learning system that combines multimedia technology and game mechanisms, focusing on teaching activities in the social field, assisting learners in reviewing Tamsui’s development history, and guide the learner to understand the story about the land of Tamsui. In order to verify the learning achievement of the proposed system, this study took the fourth grade primary school students as the experimental subjects, and randomly divided the students into the experimental group and the control group. Through the experimental results of this study, it is found that the control group's performance in terms of learning achievement was higher than that of the experimental group, but in terms of learning motivation and learning behavior, the experimental group's performance was better than the control group. It is expected that this study can be used as the reference data in future game-based learning in the social field of elementary schools, which are then used for education promotion.

Keywords: Digital game-based learning, Social Field, Teaching Affect

1. Introduction

Many scholars have integrated the means of games into the context of education through multimedia technology, and have proposed related game-based learning systems (Chen, Tsai & Chang, 2016; Prensky, 2001; Boyle, 2016), which has formed a trend in the fields of mathematics, natural science and English (Tsai, Yu & Hsiao, 2008), less is focused on the courses of history, geography or other social fields (Lai & Peng, 2015), and the teaching of such courses often constructs teaching contexts of many different national cultures or story backgrounds, while teachers can usually only supplement with video or photo explanations to improve learners’ understanding. However, it is not only abstract and difficult, but also makes the learner lose confidence in learning and have a sense of frustration to imagine the pictures of various periods and the changes of each century based only on the information of these fragments (Chiou, 2017). Therefore, there are still many topics worthy of in-depth discussion on the educational effectiveness of introducing game-based learning systems into the social field curriculum (Shih, 2013).

Based on the above, this study proposed a learning system that combines multimedia technology and game mechanisms, and takes the content of the hometown’s place name and location as the main axis, with a game-based way of walking Tamsui's history to introduce Tamsui's historical background. This kind of immersive game environment allows elementary school children to learn the knowledge imparted in the game naturally by responding to the game plot, thereby improving the learning motivation of the elementary school children, who are willing to take the initiative to learn to achieve the improvement of learning achievement; in addition, this study used a random grouping method, by which the students were divided into the experimental group (the learning group using game-based learning) and the control group (the learning group not using game-based learning) for the
after-class review work. The impact of the use of game-based learning system on the learning motivation and learning achievement of elementary school children was understood via implementing pre-test, post-test, questionnaires, interviews and observations, and in-depth discussion was made on whether this learning method can really bring about changes in learning.

2. Mackay Adventure System

Figure 1 is the system architecture diagram of the Mackay adventure, including the guidance module, plot module, question module, learning history module, feedback module and scoring module. The guidance module at the beginning of entering the game will show the learners the tasks to be completed and the learning goal to be reached. Five kinds of menus are provided in the guidance module: the first kind is the plot menu, introducing stories or events about the region; the second kind is the question menu to ask learners to answer the questions and get scores for correct answers to go to the next level, otherwise learners will lose points and stay at that level until they can proceed to the next level with enough correct answers; the third kind is the learning history menu, with which one can view the current learning progress to understand the present learning status; the fourth kind is the feedback menu to recommend the level suitable for the learner according to the learning situation and help the learner to review more efficiently; the fifth is the scoring menu, where the learner can see the his or her scores of learning at any time to master the current state of learning.

3. Experimental Results

3.1 Analysis of Learning Achievement

Before the experiment started, the average pre-test score of the experimental group was 66.29 ($SD=8.07$); the average score of the control group was 64.77 ($SD=16.07$). The t-test analysis results showed that the significance of the total score of the two groups was 0.67, which does not meet the significant standard. After the end of the experimental activities, the average post-test score of the experimental group was 67.08 ($SD=9.99$); the average score of the control group was 80.65 ($SD=7.27$). The t-test
analysis results showed that there was a very significant difference between the experimental group and the control group, indicating that the initial knowledge of the experimental group and the control group was similar before the experimental activity, but there was a significant difference in post-test, and the overall performance of the control group was higher than that of the experimental group. In addition, the Cronbach’s α value for the reliability of the research test paper was 0.76, which means that the reliability of the test paper in this study has reached above the average reliability level.

3.2 Analysis of Learning Motivation

In the overall ARCS motivation questionnaire, Satisfaction had the highest score among the four motivations, with a total average of 4.33 (SD= 0.80). It can be seen that most learners liked to learn through games and felt satisfaction from the system; Confidence was the lowest score among the 4 motivations, with a total average of 3.73 (SD= 0.80). This indicates that learners were less confident in using this system to review geography and history courses, but since the average of the highest score and the lowest score differed by 0.6, there was not much difference between the two.

Conclusion

This study introduced a set of Mackay adventure system, which is used in the primary school social field to teach Tamsui history and geography. The experimental results of this study show that the learning achievement of the traditional learning review group was higher than that of the digital game learning review group. However, in terms of learning motivation and learning behavior, the digital game learning group performed better than the traditional learning group. Through the analysis of questionnaire surveys and in-depth interviews, it is found that the difficulty of the game content will affect the level of learning achievement, and too difficult content will make the learner appear to evade learning, thus leading to a decrease in learning achievement, which is also same as the research results of Tsai et al (2008). In summary, this study believes that the difficulty of game content will affect whether learners will have the behaviors to avoid study, and finally affect the overall learning achievement.

Acknowledgment

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References


Review of Depression Recognition Based on Speech

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Abstract: In recent years, the research on depression recognition has been widely concerned through machine learning or deep learning field. This paper reviews the relevant research on depression recognition using speech as biological indicators. The current challenges in this field are elaborated to further lead the future research direction.

Keywords: Phonetic features, depression, review

1. Introduction

Depression not only affects the physical and mental health of individuals, but also leads to high rates of disability and death (Pan et al., 2018). In recent years, it is common that objective indicators are used to assist in the diagnosis of depression. Speech is a sensitive indicator, slight physiological and cognitive changes may lead to significant changes in hearing (Schneider et al., 2012). At the same time, changes in respiratory muscles will affect the glottis. Both rhythm and glottic features have been proved to be affected by depression level (Moore et al., 2008). Therefore, the weakening of the rhythm, monotonous and slow pronunciation speed indicate depression (Hall et al., 1995).

This review is mainly divided into the following parts: First, makes a brief review on speech-based depression study at home and abroad; Secondly, describes the performance of rhythmic and spectral features of depression; Thirdly, description of two different research methods; Finally, some challenges provided for future research directions.

2. Research Status at Home and Abroad

In order to inspire future research directions, this section attempts to make a brief review of the relevant literature on depression diagnosis based on speech at home and abroad.

Compared with abroad, China’s speech-based depression research started late. With the support of the National 973 Project, the Pervasive Computing Laboratory of Lanzhou University collects voice samples and analyzes them to identify depression. The Chinese Institute of Scientific Psychology uses machine learning approaches to establish an effective automatic recognition model of depression. The diagnosis of depression based on speech signals abroad is mainly the Audio Video Emotion Challenge Competition, which has been held for five consecutive years.

3. Acoustic Features of Depression Speech

Based on the results of psychological and prosody research, the most intuitive manifestation of the speaker’s depression in speech is the prosody and spectral features.
3.1 Prosody Features

Prosody features are dynamic expressions of speech. Munt et al. and other studies from the perspective of rhythmic features found that the fundamental frequency of individuals with depression will decrease. Depression can be analyzed by prosody features, such as reduced loudness, pitch change, and loudness change (France et al., 2000), as well as the fundamental frequency and prosody change of pronunciation (Mundt et al., 2007).

3.2 Spectral Features

Spectral features usually reflect the short-term features of speech signals are related to changes in muscle tone and control related to vocalization. The researchers believe that spectral features can characterize the change in the speaker's mental state. Low et.al. pointed out that spectral features are useful for the identification of adolescent depression. Höning et al. pointed out that MFCCs are a type of useful feature in depression recognition.

4. Approaches for Speech-Based Depression Recognition

4.1 Traditional Machine Learning Approaches

The approaches of traditional machine learning are to manually extract depression-related low-level descriptors (LLD). Low et al. also proposed a Teager-based Energy operator features, found that increasing the Teager energy operator features can improve the performance of depressed men by 31.35%. After the feature selection, the features are classified by machine learning algorithms. Commonly used classifiers are Gaussian mixture models (GMM) and support vector machines (SVM).

A variety of speech-based automatic prediction approaches for depression have been studied. Moore et al. and Ooi et al. studied the formation of a classification system from the combination of prosody, sound quality, frequency spectrum and glottal features. The above literature analysis shows that Teager energy and glottal features are more accurate than classifiers based on individual prosodic features. The results of these two experiments (Ooi et al., 2013) support the previous discussion that depression's effect on muscle tone and larynx control can lead to glottic flow. There are also several literatures that show the applicability of individual rhythm, sound quality, spectrum and glottal features. In literature (Stasak, Epps, Cummins, et al., 2016), GMM is used to classify a series of speech features and spectrum features. The Mel Cepstral Coefficients (MFCCs) have reached with 77% accuracy, the formant reaches 74% accuracy. Helfer et al. also showed the superior performance of GMM and SVM in the classification of depression severity.

4.2 Deep Learning Approaches

Recently, the recognition approaches of depression with deep learning have been proposed (Ringeva et al., 2015; Rejaibi, Komaty, et al., 2019). The deep learning approach is to build a multi-layer hidden neural network model and use a large number of speech samples to train the feature model to extract the most relevant features.

Several deep neural networks have been proposed. He et al. input low-level features manually extracted and high-level features extracted by DCNN together into the DCNN network, then through a joint fine-tuning layer to predict depression, get great results on a larger data set. Jain et.al. compared with BLSTM, CNN and LSTM-RNN with attention mechanism, the capsule network proved to be the most effective architecture. A novel approach is proposed (Chlasta et al., 2019), after the DAICWOZ data set is expanded, the residual CNNs with different depths reach 77% accuracy. In order to evaluate the depression level using the "Patient Health Questionnaire 8" (PHQ-8) scale for evaluating depression levels, Yang et al. proposed DCNN. To our knowledge, their approach is superior to all existing approaches on the DAICWOZ dataset.
5. Research Challenge

Looking back at the previous research in the field of speech-based depression recognition, although speech signal research has made a series of progress in the field of depression recognition, there are still many challenge worth considering.

5.1 Sample Scale

The small scale of depressive speech samples of depressed individuals is not conducive to the generalization and training the model. Each hospital can establish a unified and standardized patient health system database for data sharing, thereby improving the generalization ability of the model.

5.2 Longitudinal Control Group

In future research, a longitudinal control group should be added to increase the breadth of the population of speech prediction. Therefore, the comparison between disease types can increase the specificity of speech recognition, thereby providing effective biological indicators for clinical diagnosis.

5.3 Feature Selection

Distinguishing between depressed and non-depressed individuals is based on different features of speech. Using the appropriate feature selection approach to select the most relevant features of depression is critical to the diagnosis of depression.

6. Conclusion

In this study, relevant researches on speech-based depression recognition were summarized. Thereby, using speech recognition technology to understand the role of speech signals as biological indicators in the diagnosis, recurrence prevention and efficacy evaluation of depression, lays the foundation for the clinical application.

References


Effects of Using Rubric Forms on Evaluation Behavior in Student Peer Assessment

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Abstract: This study aimed to clarify the effect of using rubric forms on evaluation behavior by analyzing the influence of differences in peer assessment form design on student evaluation behavior. We prepared two types of evaluation form, a rubric form and a non-rubric form and compared the evaluation times. The results revealed that the behavior of evaluating multiple items in a short period of time and in the numerical order of evaluation items was more often observed when using the non-rubric form. In addition, the medians of evaluation time were higher among students who used the rubric form.

Keywords: Peer Assessment, Rubric, Evaluation Behavior, Learning Analytics

1. Introduction

Along with the spread of active learning classes, peer assessment has become popular. While peer assessment has various advantages, its reliability and validity are a major concern (Fukazawa, 2010). While conventional studies have mostly utilized evaluation scores to address this issue (Hughes & Large, 1993; Stefani, 1994; Freeman, 1995), research that analyzes peer assessment from the perspective of evaluation behavior is still scarce (Horikoshi & Tamura, 2018).

As the results in previous papers, we have revealed that each student has different evaluation behaviors. For example, some students took a long time to evaluate while others evaluated in a short time. Some students evaluated in the order of evaluation items while others did not. However, the causes or interpretations of these characteristic evaluation behaviors have not been established.

The objective of this paper is to clarify the effect of using rubric forms on evaluation behavior. In order to achieve this objective, we set the following hypotheses:

Hypothesis A: The behavior of evaluating multiple items in a short period of time in the numerical order of evaluation items is more often observed when using a non-rubric form than when using a rubric form.

Hypothesis B: A longer evaluation time is observed when using a rubric form than when using a non-rubric form.

2. Methods

2.1 Data Acquisition

In this study, a Web evaluation form was implemented and used to obtain the evaluation time for each evaluation item in a student peer assessment. This online form records the evaluation time and score for each assessment item before and after the “submit” button is clicked. This form was used in previous studies by the authors of this paper. However, in order to verify Hypotheses A and B, two types of forms were created for this study: a rubric form and a non-rubric form (Figure 1).
Figure 1. Two types of peer assessment forms used in this research (17 items in total, excerpts from the screen)

### 2.2 Experimental Design

Participants in this study were students of the “Information Literacy” course at Sophia University, Japan. In order to verify Hypotheses A and B, we conducted experiments with two conditions and collected logs in the peer assessment. The target class was divided into two parts, half of which used the non-rubric form in the first week of the experiment and the rubric form in the second week. The other half of the class used the forms in reverse order. Students in this course were divided into 12 groups, of which six gave presentations each week and carried out peer assessment.

### 3. Results and Discussion

#### 3.1 Acquired Data

Table 1 shows the number of reviews for each presenter group. It should be noted that though the groups which made their presentations in the target week of this paper were only groups A to F, there was reviewer who erroneously evaluated group G, and therefore group G also appears in Table 1. Section 3.2. verifies Hypotheses A based on Group A, while Section 3.3 verifies Hypotheses B based on groups

<table>
<thead>
<tr>
<th>Evaluation Item</th>
<th>Score (1-5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1: Was the title of the presentation appropriate?</td>
<td><img src="a" alt="Rubric form" /></td>
</tr>
<tr>
<td>Q2: Did the presenter give an appropriate introduction before moving to the main topic, and was the introduction useful for the audience in understanding the presentation?</td>
<td><img src="b" alt="Non-rubric form" /></td>
</tr>
<tr>
<td>Q3: Was the main point of the presentation clear?</td>
<td></td>
</tr>
<tr>
<td>Q4: Was the presentation well-structured and organized?</td>
<td></td>
</tr>
</tbody>
</table>

---

**Table 1.** Number of reviews for each presenter group. It should be noted that though the groups which made their presentations in the target week of this paper were only groups A to F, there was reviewer who erroneously evaluated group G, and therefore group G also appears in Table 1. Section 3.2 verifies Hypotheses A based on Group A, while Section 3.3 verifies Hypotheses B based on groups.
A to F.

Table 1. Number of reviews for each presenter group

<table>
<thead>
<tr>
<th>Presenter Group</th>
<th>Number of Reviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>53</td>
</tr>
<tr>
<td>Group B</td>
<td>53</td>
</tr>
<tr>
<td>Group C</td>
<td>56</td>
</tr>
<tr>
<td>Group D</td>
<td>51</td>
</tr>
<tr>
<td>Group E</td>
<td>53</td>
</tr>
<tr>
<td>Group F</td>
<td>49</td>
</tr>
<tr>
<td>Group G</td>
<td>1</td>
</tr>
</tbody>
</table>

3.2 Hypothesis A

To verify Hypothesis A, the evaluation behavior for each type of peer assessment form for group A was analyzed (Figure 2). In Figure 2, each graph shows the evaluation behavior of one reviewer. The vertical axis of the graphs shows the number of the evaluation item (Q1-Q17), while the horizontal axis shows the elapsed time from the start of the presentation (0 to 20 minutes). The dark shaded area of the graphs shows the presentation time, while the light shaded area shows the Q&A time. The reviewers who evaluated before the presentation started or after 20 minutes are not included in Figure 2.

To verify Hypothesis A, the evaluation behavior graphs shown in Figure 2 were classified based on whether or not they showed the behavior of evaluating multiple items in a short period of time in the numerical order of evaluation items. The graphs were classified by visual confirmation according to the following criteria.

- Evaluation in a short period of time: Includes the reviewers who completed the evaluation within one or two minutes. Reviewers who changed only one item after a certain time like S035 can be included in this category.
- Evaluation in the numerical order of evaluation items: Includes the reviewers who evaluated in one direction, in descending or ascending order. Reviewers who changed only one item like S026 can be included in this category.

Table 2 shows the results of the classification. Both types of forms were assigned to participants in approximately the same number; however, because of absence and agreement/disagreement with the study, there was a difference in numbers. Despite this difference, as shown in Table 2, it appears that the target behavior was more frequent in the non-rubric form, while other behaviors were more frequent in the rubric form. In other words, it is suggested that the type of form may have an influence on whether or not students show the behavior of evaluating in a short period of time in the numerical order of evaluation items. In order to statistically verify this, a $\chi^2$ test was performed and a significant difference was found ($\chi^2(1)= 4.1346, p<.05$).

Table 2. Comparison of target behaviors (Group A)

<table>
<thead>
<tr>
<th></th>
<th>Evaluation in a short period of time and in the numerical order of evaluation items</th>
<th>Other evaluation behaviors</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-rubric form</td>
<td>15</td>
<td>12</td>
<td>27</td>
</tr>
<tr>
<td>Rubric form</td>
<td>5</td>
<td>17</td>
<td>22</td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>30</td>
<td>49</td>
</tr>
</tbody>
</table>
Figure 2. Evaluation behavior for each type of form (Group A)
3.3 Hypothesis B

To verify Hypothesis B, the evaluation time (ET) was compared between the two types of evaluation form. In this study, ET refers to the time difference between clicking on the radio button of the first evaluation item and clicking on the radio button of the last evaluation item.

![Figure 3. Comparison of “Evaluation Time (ET)” (Groups A-F)](image)

Figure 3 shows the distribution of ETs. The left bars in each group refer to the non-rubric form users, and the right bars refer to the rubric form users. As for the distribution, there is a large variation; there are reviewers in the non-rubric form user group (left bars) who took considerable time to evaluate and there are also reviewers in the rubric form user group (right bars) who evaluated in a short period of time. On the other hand, all ET medians were higher in the rubric form users than in the non-rubric form users in all evaluation groups. In sum, ET varies depending on the reviewers. However, the median shows that the evaluation using the rubric form takes longer.

4. Conclusion

This study aimed to clarify the effect of using rubric forms on evaluation behavior. The results of the experiment clarified that the behavior of evaluating multiple items in a short period of time and in the numerical order of evaluation items was more often observed when using the non-rubric form. In addition, the median of students’ evaluation time was higher in the condition of using the rubric form.

As a future task, we would like to clarify the reasons why students who used the rubric form took longer to complete the evaluation. This may be because such students tried to make a serious evaluation or took longer to read the form because the rubric form had more characters.

References

Factors Affecting Japanese Students’ Fatigue in Online Foreign Language Presentation Courses During the COVID-19 Pandemic

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Abstract: This paper discusses the relationship between online class styles and students’ degree of fatigue during the 2019 coronavirus disease (COVID-19). A survey was conducted on first-year students of the author’s national university in Japan and the responses of 1,156 respondents were analyzed. The results indicate that time allocated for the report and/or preparation most likely contributes to the students’ degree of fatigue. For reading courses, a non-video based class style could be helpful in addressing student fatigue. In addition, network comfort is another potential factor that causes fatigue.

Keywords: online distant classes, English reading/presentation course, fatigue, network comfort

1. Introduction

Due to coronavirus disease 2019 (COVID-19), many university students have extended spring holidays and consequently have to catch up with their regular school curriculum online. Accordingly, some courses have started using videoconferencing programs and the number of institutions that have adopted such measures has increased exponentially. Other courses opt for a so-called “on-demand” teaching style, which allows students to download the videos at their convenience. In Japan, educational institutions set up a wide variety of virtual meeting platforms such as Zoom, Microsoft Teams, and Cisco Webex, in addition to strengthened learning management systems. In any case, great efforts were made to avoid stopping students’ learning opportunities. Although there are mechanical malfunctions and troubles caused by increased traffic, an increasing number of reports show that online learning opportunities during this pandemic appear to provide a new instruction paradigm with “reluctant” individual instructors.

Needless to say, the administrators, instructors, and researchers who are in charge of post-coronavirus instruction design must be thoroughly evaluated. It is pointed out in online teaching, particularly with MOOCs, that using short video clips should be promoted instead of full lectures interspersed with tasks. However, there seems to be little research so far on student “fatigue” caused by watching videos with higher concentration or attending virtual communities through videoconferencing in foreign language classes. Video-based materials are usually dual-modal and were found to lead to higher cognitive load for students (Sweller, Ayres, & Kalyuga, 2011). According to The Cognitive Theory of Multimedia Learning (Mayer, 2009) and Multimedia Learning Principles (Mayer, 2014), students are advised to make additional efforts in selecting, organizing, and integrating the limited cognitive resources in working with multimedia materials. Moreover, the cognitive-affective theory of learning from media (Moreno, 2005) claims that it enhances students’ learning process by increasing or decreasing the amount of cognitive resources necessary in dealing with multimedia materials. The primary issue raised in this paper is that watching videos for an extended period on a daily basis directly causes stress, anxiety, tiredness, and even threat, coupled with social insecurity brought about by the pandemic. Therefore, our hypothesis is that almost no emotional factor does not work, as expected from Moreno’s cognitive-affective theory of learning from media.

In fact, such report was recently published in Japan. Ito et al. (2020) found that the duration of concentrating on ICT tools is related to students’ degree of fatigue among elementary and secondary students. In their study on flipped classrooms for foreign language instruction, Furukawa and Nagatsuka...
(2016) reported that the fatigue caused by a large number of tasks in other subjects and being required to watch videos of preparation tasks every day causes a decline in learning motivation. Ono (2020) claims that students’ ICT environment and comfortable network communication affect the learning process, as they affect the visibility and clarity of sound, which are crucial for the success or failure of foreign language instruction. This paper aims to explore the factors that influence students’ degree of fatigue caused by online distant “English academic presentation and reading” classes. In line with this, a survey was conducted asking students about their learning environment, learning volume, and degree of fatigue.

2. Survey

2.1 Procedure

A survey was conducted on first-year students of the author’s national university in Japan on June 7–14, 2020. A total of 1,156 students responded to the survey and their responses were analyzed. The students’ majors ranged from humanities to engineering and also included PE, art, and medicine. 76% of the students were staying at home with their families because universities prohibited the entry of all students, although the universities were not locked out. 95% of the students had unlimited Wi-Fi access.

2.2 Question Items

The following model for validation presented in Figure 1 was developed to account for students’ fatigue.

![Assumed model for factors causing student’s fatigue](image)

Figure 1. Assumed model for factors causing student’s fatigue.

3. Results

3.1 Total number of classes and level of fatigue in a week

The average number of classes per week was M=19.5 (SD=3.2) and that of fatigue in a week was M=5.8 (a seven-point Likert Scale, SD=1.1). The correlation between these two parameters was r=.261 (p<.000). The results show that their weekly degree of fatigue was rather high and did not have a strong correlation with the number of classes in a week. It would be logical to assume that the more classes students take, the more likely they are to get exhausted because the video gets longer and they have to work with more assignments. It is important to note that 55.2% of the students indicated that they had an ache in their eyes or other parts of the body.

3.2 Class Styles and Fatigues

The results based on the number of classes for both reading and presentation classes are presented in Figure 2 below. For reading classes, some instructors chose non-video styles as shown in “PDF or paper” in Figure 2, which sharply contrasted with the presentation classes. Conversely, real-time interaction appeared to be the main priority in the presentation classes, resulting in longer videoconferences compared with reading classes.
The degrees of student fatigue depending on the class type are summarized in Figure 3.

Although the fatigue tendencies of the two classes are relatively similar, it is important to note that the fatigue level for reading classes was lower than that of presentation classes in “6.” This suggests that some reading class instructors avoided using video materials and some presentation class instructors opted for longer real-time videoconferencing. Therefore, it can be said that a non-video class style could reduce the students’ fatigue since they are already watching videos in many other subjects.

3.3 Decision Tree Analysis

Figures 4 and 5 present the results of the decision tree analysis of reading and presentation classes. The independent variables are NETWORK (network comfort), DEADLINE (time before deadline), TIME (duration of study at home), and STYLE (class style). The dependent variable is FATIGUE. As seen on the analysis of reading classes in Figure 4, TIME first divides into two groups. For higher fatigue groups, STYLE divides into the highest and second highest sub-groups. The group with the highest degree of fatigue can be characterized as having “longer videoconferencing or on-demand video classes wherein the students study for more than 60 minutes.” On the contrary, the group with the lowest degree of fatigue can be characterized as having “students who study for less than 30 minutes and have a stable Internet connection.” The time before the deadline did not matter in the classification.
On the other hand, TIME appeared to be a crucial factor in accounting for student fatigue in presentation classes. TIME > 90 min led to the highest degree of groups, regardless of class STYLE. Moreover, NETWORK played a role in dividing them into subgroups. Evidently, NETWORK could be considered crucial because it can disrupt students’ communication with their peers and instructors. Again, the time before the deadline did not matter.

![Figure 4. Result of decision tree analysis (reading class).](image)

![Figure 5. Result of decision tree analysis (presentation class).](image)
4. Conclusion

The survey results confirmed that the degree of fatigue could mainly be attributed to the time allocated for the report and/or preparation. A non-video-based class style could be helpful for students in reading courses. In the reading classes, students are required to read and thoroughly understand the text. On that account, too much focus on video or multimedia materials could lead to overload, as Mayer’s theory suggests. Additionally, in line with Furukawa and Nagatsuka (2016) findings, concentrating too much on videos could impede their learning process in both reading and presentation courses because they have to take a lot of other subjects in addition to English classes.

In the near future, an overall evaluation is necessary, including the findings of this study. For example, the examination of the proper “content” of tasks in online classrooms could be explored. Follow-up research be conducted that is of a qualitative nature, using open-ended questionnaires and interviews rather than statistical procedures in order to get to a much deeper level of detail. Anyway, this research could help instructors develop more sophisticated online course designs.

References
A New Method Design for Multi-modal Depression Auxiliary Diagnosis from Perspective of Psychology

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Abstract: Current depression diagnostic methods are subjective and single in nature. Therefore, an objective screening mechanism based on physiological and behavioral signals is needed. Through feature extraction and fusion of multi-modal data, we propose a design idea of combining the deep learning algorithm with classical psychological experiment technology, which enriches the idea of depression diagnosis and provides an objective basis for clinical diagnosis.

Keywords: Depression, multi-modal, auxiliary diagnosis, psychological self

1. Introduction

Depression is one of the most common mental disorders, which is characterized by significant and persistent depression and decreased activity. The current diagnosis of depression through the scale, such as: the Hamilton Depression Rating Scale (HAMD, Hamilton (1960)), Beck Depression Inventory (BDI) (Beck et al., 1996), Quick Self-Rating Depression Scale (QIDS) (Rush, Trivedi & Ibrahim, 2003), etc., as shown in Table 1.

Table 1. Commonly Used Depression Rating Scales

<table>
<thead>
<tr>
<th>Scale</th>
<th>Clinician-led</th>
<th>Self-Report</th>
<th>Number of items</th>
<th>Minutes complete to complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAMD</td>
<td>√</td>
<td>✗</td>
<td>17/21/24</td>
<td>20-30</td>
</tr>
<tr>
<td>BDI</td>
<td>✗</td>
<td>√</td>
<td>21</td>
<td>5-10</td>
</tr>
<tr>
<td>QIDS</td>
<td>✗</td>
<td>√</td>
<td>16</td>
<td>5-10</td>
</tr>
<tr>
<td>PHQ-9</td>
<td>✗</td>
<td>√</td>
<td>9</td>
<td>&lt;5</td>
</tr>
</tbody>
</table>

Recently, the research based on depression is dominated by biological and psychosocial factors. There are still many problems in the current theoretical research and practical application. First of all, most of the previous experimental studies on depression were carried out around psychiatry and neuroscience, ignoring the specific performance of depressed individuals in psychological self-related processing (Acarturk & Cetinkaya, 2018). Besides, it is rarely exploring the feasibility of using it as an objective detection indicator for depression diagnosis.

2. Research Objectives

Previous studies have focused on the occurrence and severity of neuropsychological impairment during the onset of depression (Coveñas & Werner, 2013). It is difficult for researchers to construct a typical attribute model of neuropsychological impairment in depressive individuals (Mucci & Giorgi, 2016). However, it is noteworthy that Northoff summarizes three characteristics of self-related processing abnormalities in depression: enhanced self-focusing, self-attribution of negative emotions, and enhancement of self-cognitive processing, as shown in Figure 1.
In addition to the above theoretical concepts, some empirical evidences also indicate that self-stimulation or self-related processing is related to cortical midline structures in the regions of abnormal brain involved in depression, including orbital medial prefrontal cortex (MOFC), ventromedial prefrontal cortex (VMPFC), etc., as shown in Figure 2.

Therefore, based on the self-learning theory of depression individuals and self-related processing abnormalities, the project proposes that depression individuals have abnormal self-processing effects. It holds that the special mode of self-related processing is a significant feature of depression individuals. In order to integrate the objective advantages of phonetic and acoustics and enrich the experience of psychological counseling, a dynamic hybrid model based on phonetics and acoustics information of depression, which integrates eye movement and head position are established. The establishment of a multi-modal recognition of depression diagnosis model based on deep learning under abnormal psychology process, to achieve a high degree of accuracy depression evaluation.

3. Research contents

Self is an important concept in psychology, philosophy, social cognitive neuroscience and other fields. Many studies have revealed that depressed individuals have cognitive bias relative to non-depressed individuals.

This research is to observe the specificity of self-related processing in depressed individuals, to construct a study of auxiliary diagnosis and recognition of depression by using deep learning to mine multi-modal features, to expand the experimental paradigm of classical self-reference processing focus on the principle of "limited goals, highlighting key points".

Among them, the first stage of research content is the theoretical study of self-related processing abnormalities (Friedman et al., 1968); the second stage of research content is the multi-modal information fusion modeling based on deep learning; and the third stage of research content is the application and validation of the multi-modal depression diagnosis and model recognition (Konstantina & Kourou et al., 2015).
4. Approach & Methodology

The technical route arrangement of this study is shown in Figure 3. It adopts technical methods such as data acquisition, feature extraction and fusion, modeling and application, evaluate and improve the model.

![Figure 3. Technology roadmap.](image)

### 4.1 Data Acquisition

Screening the subjects with unipolar depression into the experimental analysis, exclude the individuals with symptoms of mania-related self-exaggeration and other symptom individuals. The subjects’ multi-modal behavior data were obtained through different stimulus tasks under self-related processing materials. Recording is done in a recording studio. As shown in Figure 5.

![Figure 4. The subject sits in a professional recording studio.](image)

### 4.2 Feature Extraction and Fusion

Considering the extraction of multi-modal features and the particularity of the subjects, extracting the multi-modal behavior features that reflects the abnormal self-processing of depressed individuals (Sahu et al., 2016). Among them, the analysis of acoustic feature mainly focuses on the feature of rhythm, frequency spectrum and sound quality, as well as eye appearance feature, head posture tracking trajectory as the input basis of the training of computer neural network model. The overall process is shown in Figure 6.

![Figure 5. Feature extraction and fusion.](image)

### 4.3 Modeling and Application

Based on the obtained multi-modal behavioral feature of depressed individuals that have been reduced in dimension, normalized and fused as the original feature input of the model, which is processed by
multilayer nonlinearity, combined with the recognition task of multi-modal auxiliary diagnosis of depression under abnormal psychological self-processing, and the classifier is constructed by the feature representation of automatic learning to achieve the task of classification and recognition, as shown in Figure 6.

![Figure 6. Modeling and application.](image)

4.4 Model Evaluation and Improvement

Referring to the existing application strategies in the field of natural language processing, for the deep learning model established in the previous link, the project team will evaluate and improve this model. The process steps are roughly divided into check model, model initialization, model optimization and adjust model, as shown in Figure 7.

![Figure 7. Model evaluation and improvement.](image)

5. Challenge

Therefore, establish a multi-modal behavior database combining speech, eye movement, head posture and other multi-modal behaviors is one of the challenges facing this research. Additionally, explore the perception, recognition mechanisms of multi-modal information from audiovisual and contextual to find the abnormal and unrelated factors of self-processing dependent on multi-modal behavior characteristics realize the study on classification and recognition of diagnosis depression will be another challenge of this research.

Acknowledgements

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Promoting Critical Thinking Skills with Socially Shared Regulation of Learning in Computer Supported Collaborative Learning: A theoretical Framework

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Abstract: This study, under the guidance of social constructivist learning theory, proposes a theoretical framework that incorporates social shared regulation of learning as the independent variable to promote students’ engagement of critical thinking. The proposed theoretical framework is to assist other practitioners to apply socially shared regulation of learning in computer supported collaborative learning environment to enhance students’ critical thinking skills.

Keywords: Critical thinking, socially shared regulation of learning, computer supported collaborative learning, theoretical framework

1. Introduction

Critical thinking refers to the purposeful judgmental process with interpretation, analysis, evaluation, inference, explanation and self-regulation (Facione, 1990). Despite its significance for school performance, workplace and personal life (Bassham, 2019; Murawski, 2014), studies (e.g. Gelder, 2005; Xue & Fang, 2019) indicate that there is still a lack of critical thinking skills among students. Computer supported collaborative learning (CSCL) has recently been recognized to help improve critical thinking skills by providing learners with space to share information, express opinions, exchange ideas and make evaluations in group work (Yu, Wang, Huang, & Hu, 2014). Besides, it allows students more time to carry out the deep and reflective thinking (Oh, Huang, Hedayati Mehdiabadi, & Ju, 2018).

However, critical thinking skills are not prevalent in CSCL because students are not able to involve in the effective social interaction spontaneously (Maurino, 2007; Murphy, 2004). The meaningful CSCL requires socially shared regulation of learning (SSRL) (Hadwin, Järvelä, & Miller, 2011). In SSRL, group members jointly plan, monitor and evaluate their learning and thinking process, thus promoting students’ involvement in social interaction along with the accomplishment of the learning tasks (Isohätälä, Järvenoja, & Järvelä, 2017). Therefore, this study presents a theoretical framework to promote critical thinking skills with the integration of SSRL in CSCL environment.

2. Literature review

2.1 Social constructivist learning theory and CSCL

Social constructivist learning theory, discovered by Vygotsky (1978), emphasized that “social interactions are critical, and knowledge is constructed between two or more people” (Schunk, 2012). CSCL is rooted in social constructivist learning theory (Vygotsky, 1978) in which learners are expected to interact in group to achieve the common learning goal and students acquire more knowledge than learning individually (Udvari-Solner, 2012). It breaks down the limitation of time and space in collaborative learning (Kreijns, Kirschner, & Vermeulen, 2013) and supplies a platform for learners to share and deepen their understanding (Bereiter, 2005).

Based on social constructivist learning theory, the success of CSCL has two premises. Firstly, learners should work as a team. They are engaged in a goal-oriented cognitive process in which they share knowledge and understanding and work on the learning task. Secondly, learners should be positive...
with motivation gained from the return of learning outcomes at the cost of time and effort for the interaction with others (Kreijns et al., 2013). This means merely dividing learners into groups and putting them under CSCL environment do not necessarily result in meaningful social interactions for lack of the involvement and responsibility to fulfil the task (Morris et al., 2010). Therefore, SSRL is required in CSCL (Hadwin et al., 2011).

2.2 Socially shared regulation of learning and critical thinking skills

SSRL occurs when group members regulate their learning collectively. Group members continuously adjust their cognition, metacognition, emotion, motivation, behaviour, etc. in the learning process so as to complete the learning task together (Isohätälä et al., 2017). It promotes social interaction among group members in CSCL environment.

SSRL has the metacognitive nature (Järvelä et al., 2014), which is known as the shared metacognition regulation. Metacognition is the cognition of cognition (Flavell, 1979). Shared metacognition involves key regulation skills such as learners’ shared task planning, shared task monitoring and shared task evaluation. (De Backer, Van Keer, & Valcke, 2014).

Critical thinking is a cognitive process (Garrison, Anderson, & Archer, 2001) and is supported by metacognition. In CSCL, students have to critically judge each other’s argument and reasoning through which their metacognition are shared and SSRL comes into being (Khosla & Volet, 2014). Current studies on SSRL mainly focus on its effects on promoting students’ knowledge construction (Grau & Whitebread, 2012; Zheng, Xing, & Zhu, 2019), group performance (Panadero & Järvelä, 2015) and problem solving (Panadero, Kirschner, Järvelä, Malmberg, & Järvenoja, 2015). The research regarding the effect of SSRL on critical thinking skills in computer supported collaborative learning is still lacking.

3. Theoretical Framework

Drawn from the previous literature research, the theoretical framework discussed in this paper is shown in Figure 1.

![Figure 1. Theoretical framework for promoting critical thinking skills with SSRL in CSCL](image)

4.2 Social constructivist learning theory as the theoretical basis

According to social constructivist learning theory by Vygotsky (1978), human’s advanced cognitive abilities (critical thinking skills) are developed in social learning activities. Based on this concept, CSCL environment is used as the social learning setting for students to mutually construct knowledge and thinking (Gauvain, 2020).

In CSCL environment, group members jointly take part in collaborative learning tasks and produce shared meaning and regulation through interactions between group members (Lee, 2014). Its focus lies in the shared outcome rather than the individual’s presentation, which is in line with the social constructivist learning theory (Nolen & Ward, 2008).
4.3 **SSRL as the independent variable**

SSRL occurs in collaborative learning tasks in CSCL environment. As shown in Figure 1, in SSRL, learners deliberately adopt shared metacognitive strategies of planning, and evaluating to regulate their cognition (thinking) (Hadwin et al., 2011).

In shared task planning, learners collectively determine strategies and make plans for solving the problem. Shared task monitoring focuses on the diagnosis and control of learners’ perspectives, progress, and collaboration with the aim of identifying inconsistencies in the collaborative learning process and optimizing the execution of collaborative task. Shared task evaluation is the group’s comment judgment, mainly focusing on the collaborative evaluation of task results, task processes, and collaboration among the group members (Chen, Luo, & Zhang, 2019; De Backer et al., 2014).

4.4 **Critical thinking skills as the dependent variable**

This study attempts to propose a theoretical framework to promote students’ critical thinking skills. In this study, Facione’s model of critical thinking skills (Facione, 1990) is applied because it covers the collaborative learning setting (Facione, 2015) and focuses on the online group interaction (Hussin, Harun, & Shukor, 2019). This model suggests 6 critical thinking skills which are interpretation, analysis, inference, evaluation, explanation and self-regulation.

4.5 **Discussion: The interrelationship of social constructivist learning theory, SSRL and critical thinking skill in CSCL**

As shown in Figure 1, CSCL environment provides the working space for social learning activities and learners communicate through computer networks with the purpose to achieve the shared learning objective (Kirschner & Erkens, 2013). To co-construct the shared learning outcome, learners are required to collectively regulate their learning by virtue of the shared planning, monitoring and evaluating (Hadwin et al., 2011). While adopting the metacognitive strategies, learners involve in critical discourses that emerge in their interactions and their thinking is regulated. In other words, to reach the shared learning outcome, students need to make analysis and inference, give explanation and interpretation, evaluate and justify different opinions as well as make reflections, which manifest the critical thinking skills. All the above variables center around social interaction which is the gist of social constructivist learning theory that humans learn through interaction with others (Vygotsky, 1978).

This theoretical framework can be potentially used to design CSCL with the aim to promote learners’ critical thinking skills. Thus, future research will be carried out to confirm the function of SSRL in the improvement of critical thinking skills.

5. **Conclusion**

Critical thinking skills are crucial for one’s life. Therefore, it is meaningful to probe a theoretical framework aiming at enhancing critical thinking skills. In this study, based on social constructivist learning theory by Vygotsky (1978), SSRL (Hadwin et al., 2011), critical thinking skills (Facione, 1990) are utilized as the variable in the circumstance of CSCL. It is to the benefit of practitioners in designing their teaching and learning in which students’ critical thinking skills are fostered in online social learning environment. This theoretical framework will be tested in the real classroom scenario for future work.

**References**


Development of a Dashboard on a Mobile Collaborative Science Inquiry App – m-Orchestratel

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Abstract: This work-in-progress paper presents the design of a dashboard on a mobile collaborative science inquiry app – m-Orchestratel, where five inquiry-based learning phases are embedded, namely: WeEngage, WeCollect, WeAnalyse, WeExplain and WeReflect. Further improvement of the dashboard and future work is presented.

Keywords: Dashboard, collaborative science inquiry, m-Orchestratel app

1. Introduction

Despite that increasing studies have been conducted in improving learners’ collaborative science inquiry with technology, these studies could hardly allow the students to visualise their collaborative learning process. Although existing studies have developed dashboards to demonstrate students’ learning, few dashboards have been especially designed for students and could show real-time progress of inquiry effectively during investigation and collaboration. Thus, our research team developed a learning dashboard running on mobile devices (currently mainly for tablets) with both iOS and Android operating systems to visualize the student real-time collaborative inquiry-based science learning. The dashboard is crucial for mediating student collaborative inquiry process at critical inquiry stages.

2. Relevant Studies

2.1 Issues of Collaborative Science Inquiry in a Mobile Learning Environment

The literature on mobile technology supported collaborative inquiry learning indicates that inquiry-based learning in a collaborative learning environment leveraged by mobile technologies could help enhance learners’ conceptual understanding, collaboration, and problem-solving skills across different settings (Song, 2018; Wang, Duh, Li, Lin, & Tsai, 2014). However, because learners learn in a mobile learning environment, it is hard for them to self-monitor their learning progress across individual, group and class levels, and adapt their learning behaviours just-in-time.

2.2 Studies about Learning Dashboards in Teaching and Learning

In recent years, with the increasing amount of data to be aggregated using learning management system, empirical studies on learning analytics have been prevalent. Learning analytics is defined as the collection, analysis and visualisation of big data produced by students to generate useful information and identify potential issues for prediction and pedagogical decision-making (Ferguson, 2012). In Schwendimann et al.’s (2017) literature review about learning dashboard research, it was found that 91 percent of the studies on learning dashboard research, it was found that 91 percent of the studies on learning dashboard (50 out of 55) targeted formal learning, and over half of the 55 studies addressed learning in higher education settings. The purposes of learning dashboard were for self-monitoring, monitoring others and administrative monitoring. However, very few studies linked the learning analytics of dashboard directly with student learning outcomes or learning-related constructs. In addition, few studies addressed learning dashboard across individual, group and class...
levels. Thus, the adoption of learning dashboards and their impact on learning across different levels is under-explored and worthy of research. In this light, this study aimed evaluating the dashboard using visualization plugin to allow learners to monitor their learning progress and adapt their learning behaviours on a mobile collaborative science inquiry app, which, in turn, would enhance their collaborative inquiry learning. The app was termed as m-Orchestrator app developed by our research team to orchestrate collaborative science inquiry pedagogical practices in a mobile learning environment.

3. Design of the Dashboard

The developed dashboard locates at the project homepage of the m-Orchestrator app so that users can view it when entering a project or returning from the views of five collaborative inquiry phases: “WeEngage, WeExplore, WeAnalyse, WeExplain, and WeReflect” (refer to Figure 1). It consists of two parts, (1) group information (see Figure 1), and (2) updates of inquiry activities (see Figure 2). The dashboard can inform users of the inquiry status at individual, group, and class levels, as well as updates in each phase.

3.1 Group Information and Completion Rate

The first part shows information about group members and task completion rate, which could help users know the status of groups in the same class at a glance. The information of group members is retrieved and listed. The dashboard presents task completion rate of a group computed from the results of the three statuses of tasks (“pending”, “in-progress” and “completed”) reported by students, because students mainly plan their inquiry tasks in WeCollect phase (see Figure 3). All new tasks are set in “pending” as the default status. When students start or finish a specific task, the completion status can be changed to “in-progress” or “completed” (see Figure 4). Then, the completion rate will be refreshed on the dashboard.
3.2 Updates of Inquiry Activities

The second part of dashboard presents the ten newest updates of each inquiry phase, which are “WeEngage, WeExplore, WeAnalyse, WeExplain, and WeReflect” on the dashboard. Users can switch phases by clicking the button in five phases on the dashboard (see Figures 1 and 2). Students can publish, edit or delete notes and mind maps in a certain phase. These contents and actions will be stored in the database of the m-Orchestrate app and displayed in the exact phase on the dashboard. Besides, the notes and mind maps as general functions are deployed in the five inquiry phases. The captured user behaviours (e.g. division of tasks, updated data spread across the five phases also show on the dashboard. It is noted that the learning activities are not arranged by time, but by inquiry phases because the inquiry activities in each phase share similar tasks and objectives, which can be interpreted more straightforward. Nevertheless, the students’ inquiry process in the five phases is not linear, which means that the student does not need to complete his/current tasks in a specific phase before moving to the next. Students may leave the ongoing phase pending, then jump to other phases according to their inquiry needs.

4. Conclusion and Future Work

This article presents the features of the dashboard developed on the m-Orchestrate app for students to enhance their collaborative inquiry-based learning in science. The developed dashboard presents group members, the completion rate of groups, and the updates in each inquiry phase. However, the current design is still far from data to actions. Three features will be developed in the next step to make more actual impact on student inquiry-based learning. First, we will deploy two extra filters to the dashboard for display updates of a specific group or member. Second, we will add several indicators to quantify and evaluate some key concerns (e.g., use of notes and mind maps, collaboration, and communication) in students’ inquiry processes. Third, the dashboard will incorporate game-based assessment (such as scores on leaderboards) to motivate students’ inquiry learning at group and class levels. According to the logged behaviors of students’ inquiry, the proposed indicators will be defined by researchers via learning patterns. After these indicators are implemented in the dashboard, related parameters will be recognized from datasets and calculated automatically based on preset algorithms. The improved dashboard is expected to provide students more insights into their inquiry process by addressing these concerns with more explicit indicators.

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References

Analytics of Certification Courses within Higher Education

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Abstract: In this paper, we describe our University’s experience based on the institutionalization of industry-recognized certifications as part of the curriculum, specifically for a number of professional computer education courses of students. This is the initial phase of a longitudinal research that we intend to do with the goal of investigating factors that contribute to the effective use of industry certification courses and exams as a supplemental learning infrastructure as it provides formal learning the very relevant practice, resources and data that will inform instructional/curriculum design. We found that academic performance of students in professional courses is predictive of the MTA passing rates when the course content is aligned to that of the certification exam’s topics. With the findings of the data analysis performed in this initial study, we recommend some considerations and guidelines in integrating appropriate certifications to the curricula for higher education using it as a tool for adapting academic learning outcomes to the requirements of the industry.

Keywords: Academic Curriculum, IT Certifications, Certification performance predictors

1. Introduction

Amidst the 4th Industrial Revolution, academic institutions find ways to equip their students with competencies that make them qualified players in this knowledge-based economy. Graduates of Higher Educational Institutions are expected to have high skills that go beyond basic and generalist skills. Industry certifications are the tool of choice to attain industry-required skillsets and recognition of qualifications (Daniels, 2011; Saleem, Gercek, \& Varma, 2015). While some recruitment executives still give more weight to formal college degrees than industry certificates (Bartlett, 2002), most employers still recognize the value of appropriate certifications for students that they will be hiring (Wierschem, Zhang, \& Johnston, 2010). Industry certifications within formal education settings brings about recognized advantages to students most especially in select fields and careers like those in Computing and Information Technology. Certifications are usually the most sought-after solutions to better equip university graduates and make them more marketable to future employees (Randall \& Zirkle, 2005). However, some practitioners believe that industry certifications and formal academic education are mutually exclusive (Hitchcock, 2007) and are not complementary with each other (McKenzie, 2006). The global growth of IT industries paved the way for a highly competitive job market for graduates of universities in the global setting. Students in this field of study are faced with the threat of obsolescence as the skill sets are dictated by the rapidly changing requirements of industries all over the world. To respond to this threat, major players in the IT industry have come up with certifications to ensued that the required and updated minimum skill sets are met by its workforce. Such certifications not only measure the readiness of the graduate to become part of the labor force, but also validates the effectiveness of formal education as a preparatory medium for prospective workers requiring a specific skillset.

The College of Computing Education of our University has integrated Microsoft certifications specifically the Microsoft Technology Associate (MTA) in the curricula of students from their first year up to the third year into their programs since 2014. The MTA Certification is one of the entry-level types of certification exams that cover the fundamental skills and knowledge of students in technologies like networking, databases and security fundamentals. Specific to our University’s experience, we present the performance of our students in this particular certification exam. Analyze the performance
across the years and use the results of this analysis to come up with curricular recommendations pertinent to institutionalizing industry certifications in the academe.

2. Objectives of the study

With the analysis of the students’ academic performance, and a vendor-specific certification course data used as a supplemental learning and assessment tool within a formal course, we intend to:

1. Determine any relationship that may exist between the students’ academic performance and their MTA performance; and
2. Recommend curriculum-pertinent policies and practices based on the results of this study to improve future MTA performance of students and possibly, other similar industry-certifications appropriate for their fields of study

3. Data Collection

We gathered the academic grades and MTA certification course logs and performance of an overall total of 389 students for the period 2014-2019 for the following professional courses: Database Management (IT 225L) 112 students, Networking (CS311L) 182 students and Computer Security (IT329L) 98 students. These classes are heterogeneous in nature and were comprised of Bachelor of Science in Computer Science and Bachelor of Science in Information Technology students. The dataset was preprocessed, cleaned and checked for normality and multicollinearity.

4. Data Analysis

For the database management course for the years 2014 to 2019, we found that 89.74% passed the MTA certification exam and 90.60% earned a passing grade for this course. For the networking professional course, we found that 64.84% passed the MTA certification and 87.36% passed the course. For the Computer Security professional course, only 13% and 88% passed the MTA examination and the course, respectively. Performing a trend (linear) regression shows that every year for the duration of this study, there is an increase in the academic performance and the certification exam results for the students who were enrolled as they took the certification course and exam and the performance within the course was predictive of the MTA exam performance. A student’s academic performance is measured though his/her grade point average (GPA). The computed correlation coefficient (r) equals .295, indicates some linear relationship at p<0.05 level. This illustrates the relationship between the GPA and the MTA exam (r=0.295, p<0.05). When reviewing the predictive ability of GPA on MTA results of students, of which, the predictor has an odd ratio of 1.100 times more likely to pass or fail the GPA and MTA within the confidence interval of 1.065 and 1.136. This indicates that the GPA is a significant predictor of the MTA certification exam performance. We also labeled the data in terms of the instructor having previously taken and passed the MTA certification and found that instructors that passed the MTA certification, had classes where there was a high percentage of MTA passing rate and higher academic and course performance of students. We intend to probe into this more in the next phase of this study and look at instructor-related factors like methods of instructional delivery particular to the instructor.

5. Summary of Findings

There is a trend from the analysis that shows the improving performance of the students in the academic courses and the MTA examination. We found that the GPA is predictive of the MTA performance of the students. A qualitative analysis of the results also leads to the conclusion that there is a possible
existing alignment between the learning outcomes and competencies of Database Management and Networking courses to the competencies tested for in the MTA. In the same manner, there may exist some misalignment between competencies in the Computer Security course and the MTA certification as the students who took the Computer Security had a lower MTA passing percentage compared to the other 2 courses. We will be looking further into the mapping of these course competencies with the MTA competencies in the next phases of this work. We further found that instructors who passed the MTA may have contributed to the performance of the students in the same MTA exam. This finding corroborates similar work that states that instructors/teachers have salient implications on the effectiveness of using certifications as a supplemental learning tool in post-secondary education (Anderson, 2009; Randall & Zirkle, 2005).

6. Conclusions and Recommendations

To further improve the implementation of industry certifications in the University, we posit the following recommendations based on the results of this initial study: Firstly, to replicate the competencies and learning outcomes of industry certification exams in the curricular course offerings. The MTA exam has been published to have the fundamental topics in IT and Computing across different tracks like, IT infrastructure, Systems Development and Database management. Given these tracks and the embedded competencies within them, we found that our courses are aligned with industry requirements. Further, we also found out that the Computer Security course may need to be reviewed and validated with what the industry demands. Lastly, to institutionalize mechanisms by which instructors are at par with industry requirements as we have found that classes where instructors are certified MTAs have greater passing percentages than those handled by instructors who do not have the said. In conclusion, we recommend that academic institutions treat certification exams as a tool to validate the actual content of instruction being delivered to the students. It is a critical assessment that measures if the learning outcomes are aligned with industry standards. When designing curricula, the appropriateness of certifications to the students’ career paths should be given more consideration and not merely aim using certificates as a technical qualification for marketability (Plice, R. K., & Reinig, 2007). For our future work, we intend to investigate other factors that will contribute to the optimization of the use of industry certification as a supplemental learning platform. We also intend to individually model each of the course separately to more accurately inform instructional and/or curriculum design. There could be other factors in play that we intend to investigate as we pursue this research, e.g. prior work experience, quality of student preparation, duration of use or exposure to the certification course as a supplemental learning tool, etc.

References


Implementation of an Academic Counselling Online Platform

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Abstract: Academic stress is a factor that can affect the mental health of students. It may take the form of peer pressure, doing poorly in tests, or even submitting a requirement late. With the current coronavirus pandemic, most schools have opted to do online classes. However, some students find difficulty in doing online classes due to the lack of resources. Other services such as counseling are also put to a halt. Monitoring the students’ mental health is now more difficult with the current online class setup. For this purpose, we developed web-based mental health monitoring platform for educational institutions, which can be used by mandated school personnel e.g. guidance counselors to continue to address the mental health concerns of students brought about by academic stress. With the deployment of this platform, we found that the students respond positively to online sessions and consult with their academic counselors as we intended to replicate the dynamics of face to face sessions. We have deployed this platform in a specific University in the Philippines and to be able to provide this essential service to the student constituents even at this time of pandemic. We also designed the platform to incorporate topic models and sentiment for analytics and visualization of the anonymized data to inform the University as to the necessary improvement and needs of the students pertaining to their mental health concerns.

Keywords: Guidance counseling, web application, academic mental health, sentiment analysis, topic modeling, data mining tools

1. Introduction

1.1 Background of the Study

Academic institutions offer guidance counseling to its students to monitor overall wellness, academic performance and other academic related concerns. It is facilitated between a student and a counselor face-to-face within a room to discuss pertinent matters. As guidance counseling is part of a service that the school offers, it is one of the services that has been difficult to provide due to the coronavirus pandemic. The only solution, at present, is the implementation of counseling on an online platform. To address this need, a chat web application is designed and developed. This chat web application is a convenient way to have online student consultation sessions. To also automatically monitor the overall academic mental health of students, automated topic modeling and sentiment analysis of the transcripts of the sessions are performed. Data protection and privacy issues are addressed as the overall models are anonymized and individual students can, in no way, be specifically identified when statistics of overall academic performance and wellness summaries are generated. These statistics will inform the academic administrators in instructional design and pedagogical design such that their students’ academic and overall performance and wellness are given due consideration.

1.2 Objectives

In the design of this application we considered the following:

- What are the user and systems requirements and development considerations for these online academic counseling sessions?
- What are the factors affecting the general student population that will be generated according to the topics which are extracted from the online chat counseling sessions?
2. Review of Related Literature

2.1 Academic Guidance Counseling and Monitoring

Guidance and counseling services are an essential educational tool in the development of a child’s orientation (Nkechic, Ewomaoghene & Egenti, 2016). It is a service that assists students throughout their academic journey in order to aid in their development and let them further improve within their capacity (Demir & Can, 2015), i.e. online counseling (synchronous and asynchronous), web-based interventions, internet operated therapeutic platforms, and other online activities such as online support groups and online health assessment (Barak, Klein & Proudfoot, 2009).

2.1.1 Need for Counseling

The suspension of in-person and face to face classes can have adverse psychological effects among students as they are more prone to feel intense emotions like frustration, anxiety, and betrayal or struggle with loneliness and isolation, which detaches them from their friends and teachers. Students that receive on-campus counseling lose access to this essential service, may jeopardize their study program and possibly contribute to poor academic performance, hence the need to provide counseling even at a distance (Zhai & Du, 2020).

3. Online Platform Requirements, Design and Implementation

Focused group discussions and user interviews were conducted to build the process flow model of the online platform. The chat function is an essential part of the website. The counselors agreed that there is a need for the chatbox or message box as it will serve as their medium for online counseling. A student can message any counselor. In the chatbox, the student is able to attach files in their messages, such as images or documents. The chat sessions can support both synchronous and asynchronous messaging. Through synchronous messaging, counselors and student counselee may interact in real-time. Having asynchronous messaging students can leave a message to the counselors even when they are not available and for counselors to be able to respond to students even when the student is not online.

The counselors also wanted to add two sections to the website, the Readings and Update section. In the Readings section, the counselors can post articles or other items they wish to share with the students.

NDMUGuide is the site name for the counseling platform (see screenshots in Figure 1). The design of the web application was based on the results of the requirements gathered and planned. It can be accessed through the link https://www.ndmuguide.com. When creating the website, the researcher chose WordPress and Tawk.To as the platforms to be used in NDMUGuide in order for the website to be easily manageable by the guidance counselors without help from a professional and it can also be easily replicated by other schools if they want to offer a platform for online counseling. The chat function uses Tawk.To which is a free chat live software which was founded by Robert D’Assisi. Tawk.To was integrated directly to the NDMUGuide website.
We have made initial sentiment models using the Vader valence scores (Gilbert & Hutto, 2014). We also built initial topic models using the genism (Řehůřek & Sojka, 2011) library in Python. In the subsequent phases of this study, the automated topic or “themes” and general sentiments of the students will be extracted, analyzed, and presented via visualization and reports will be designed so as to inform instructional design and academic administration decisions.

4. Findings and Future Work

At present, students and academic counselors are using the online platform. With the platform, the essential counseling and monitoring services of the University are continuously provided despite the disruptions that the pandemic has brought about. The subsequent part of the work for this study is to perform appropriate visualization of the general themes of the concerns of the students, as well as their sentiments. With this valuable feedback, instructional design will be made appropriate to factor in the pressing concerns expressed by the students via this online platform.

References

Problems in Educational Use of Spherical Video-based Immersive Virtual Reality in Practice: The LIVIE Experience

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Abstract: This work-in-progress paper presents the work that we have conducted in the first research cycle (the first year) of a piece of 2-cycle design-based research (DBR) on implementing LIVIE—a pedagogical approach to integrating spherical video-based immersive virtual reality (SV-IVR) into geography education. The entire DBR involved 9 teachers (from 9 different Hong Kong secondary schools at 3 different academic categories) and their Grade-10 classes in two consecutive school years. In this paper, we focus on discussing the problems unfolded in the implementation process of LIVIE in Cycle 1. The findings not only shed light on how to improve and optimize the current teacher facilitation acts in LIVIE to be enacted in Cycle 2 of the DBR, but also alert educators and researchers to the potential impeding issues regarding the educational use of SV-IVR in practice.

Keywords: Spherical video-based immersive virtual reality (SV-IVR), design-based research (DBR), LIVIE, geography education, secondary education

1. Learner-Immersed Virtual Interactive Expedition (LIVIE)

Immersive virtual reality (IVR) possesses rich educational potential (Alexander et al., 2019; Chang et al., 2020). As a subset of IVR, spherical video-based IVR (SV-IVR) provides school teachers with an affordable alternative to harness IVR-based elements in their teaching practices. Grounding on Pedaste et al.’s (2015) enquiry-based learning model, we proposed Learner-Immersed Virtual Interactive Expedition (LIVIE), a pedagogical approach to incorporating immersive and interactive virtual enquiry-based fieldwork in geography education with SV-IVR (Jong et al., 2019). LIVIE is composed of 5 pedagogical phases: (I) Communication, (II) Orientation, (III) Investigation, (IV) Explanation, and (V) Reflection. Phases II to V operate sequentially, involving students’ self-directed learning with SV-IVR outside the classroom; while Phase I interlaces Phase II to V, involving both teacher scaffolding and group-based student support inside the classroom. As for the context of geography curriculum learning and teaching in Hong Kong secondary schools, normally, a 12-day teaching cycle is used to cover 1 curricular module (with 4 face-to-face lessons therein). Figure 1 shows the implementation design of LIVIE in a teaching cycle, while the full design description has been documented in our recent publication (Jong et al., 2020).

2. Research Design

Design-based research (DBR) is a collective effort between both researchers and teachers to initiate, evaluate and optimize educational developments/applications, such as curricula, pedagogies, or policies, so as to secure the implementation of the developments/applications to be practical and sustainable in schools (Bakker, 2018; Jong et al., 2006). In this 2-cycle DBR, we recruited 9 geography
teachers (from 9 different secondary schools at 3 different academic categories\(^\text{14}\)), with comparable academic background and teaching experience. All of them had participated in our LIVIE introductory workshop. We adopted Design-based Research Collective’s (2003) stage-based approach to shaping the 2 iterative rounds of Design, Enactment, Analysis and Redesign. Observing the page limit (3 pages), we can only briefly describe the works conducted in the first 3 stages in this cycle.

**Design.** In each school, we offered the teacher refresher training on LIVIE. Then, the teacher participated in a quasi-experiment\(^\text{15}\) in which he/she piloted to implement LIVIE (Jong et al., 2020). After that, we assigned the teacher a curricular module, as well as reviewing together with him/her (i) the LIVIE materials that we had developed for the assigned module and (ii) the existing facilitation acts in LIVIE based on his/her school context.

**Enactment.** In each school, we supported the teacher in implementing LIVIE to facilitate a Grade-10 class to study the assigned module. We conducted data collection inside and outside the classroom during the entire implementation process from both teacher and student sides\(^\text{16}\). We also carried out formative analysis on the collected data and offered the teacher timely information for adjusting his/her facilitation acts if necessary.

**Analysis.** After the implementation, the class took the knowledge test\(^\text{17}\) in which the questions were customized from the Hong Kong geography public examination questions related to the assigned module. We also further conducted in-depth post-learning interviews with some students to probe into their LIVIE experience. Finally, we carried out summative analysis on all collected data.

![Figure 1. Implementation Design of LIVIE in a 12-day teaching cycle](image)

### 3. Findings

We only focus on reporting the problems unfolded during Cycle 1’s Enactment stage in this work-in-progress paper, as summarized in Table 1. In Cycle 1’s Redesign stage, we set up 3 working groups with the 9 teachers to discuss and address these problems. We grouped the 3 teachers at the same schools’ academic categories to (i) discuss the findings obtained in Cycle 1, and (ii) worked together to

\(^{14}\) Hong Kong secondary schools are divided into 3 academic bands; Cat-1, Cat-2, and Cat-3 are respectively the upper, middle, and lower.

\(^{15}\) After the training, most of the teachers deemed that it would be much better if they could gain some real LIVIE implementation experience before enacting the facilitation work in the Enactment stage of the DBR. Also, they were interested in knowing, in particular, would the pedagogical effectiveness of LIVIE be really better than the conventional textbook-based approach’s. As agreed by all teachers and their schools, before the Enactment stage in Cycle 1, each of them piloted to implement LIVIE to teach a curricular module via a quasi-experiment with 2 Grade-9 classes (Jong et al., 2020).

\(^{16}\) The data included (i) self-reported data [teacher’s think-aloud reflection, just-in-time student-researcher/teacher-researcher chat, multiple purposes student/teacher interviews]; (ii) observational data by the researcher; and (iii) documentary data [teacher’s access logs, and students’ virtual expedition proceedings, etc.].

\(^{17}\) The test result in this cycle will be compared with the one in Cycle 2.
derive interventions for optimizing LIVIE. The “optimized” teacher facilitation acts in LIVIE to be enacted in Cycle 2, and their corresponding effectiveness will be presented and discussed in our upcoming papers.

**Table 1. Problems Unfolded during the Enactment Stage in Cycle 1**

<table>
<thead>
<tr>
<th>Cat.1 Schools</th>
<th>Cat.2 Schools</th>
<th>Cat.3 Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Some students from low SES (socio-economic status) families were inexperienced in using the borrowed smartphones, having trouble in operating the App for accessing the SV-IVR materials in Phases II, III, IV and V. In the research, the majority of the students used their own smartphones to access the SV-IVR materials. (<em>Remark: For students who had no smartphone or their phones were not able to install the App for accessing the materials, they could borrow one from the research team.</em>)</td>
<td>- Some students regarded that the contents covered on Days 1 and 4 (i.e., Phase I: In-class Connection and In-class Conceptualization) were not concrete enough to prepare them for conducting the out-of-class enquiry tasks required in Phase II and Phase III.</td>
<td>- Some students felt dizzy after conducting the virtual expeditions.</td>
</tr>
<tr>
<td>- Some students complained that the App was not quite user-friendly; it took time for them to figure out how to use their head movements to interact with the SV-IVR materials.</td>
<td>- Some students just partially completed the out-of-class enquiry tasks required in Phase II, Phase III, and/or Phase IV, impeding their in-class participation on Days 4, 7 and 10.</td>
<td>- Some students misunderstood the instructions embedded in the O-Scaffolds and I-Scaffolds respectively in Phase II and Phase III, and eventually came up with serious misunderstandings of some important conceptions and findings.</td>
</tr>
<tr>
<td>- Some students were less motivated to learn with LIVIE because they realized that the conventional textbook-based approach was more effective to help them get higher marks in the geography examination.</td>
<td>- Some students misunderstood the instructions embedded in the O-Scaffolds and I-Scaffolds respectively in Phase II and Phase III, and eventually came up with serious misunderstandings of some important conceptions and findings.</td>
<td>- Some students were only interested in participating in the virtual expeditions but not participative in the in-class activities on Days 1, 4, 7, and 10, and eventually came up with major misconceptions about some fundamental geographic knowledge.</td>
</tr>
<tr>
<td>- Some students regarded that the O-Scaffolds in Phase II were not effective enough to guide them to gain a comprehensive overview of the geographic background of the module.</td>
<td>- Some students were unwilling to interact with their groupmates on Day 7 (i.e., Phase I: In-class Peer Discussion).</td>
<td>- Some students did not understand the instructions embedded in the O-, I-, E-, and R-Scaffolds, and eventually skipped some or all out-of-class enquiry tasks required in Phase II to Phase V.</td>
</tr>
<tr>
<td>- Some students in the same group had divergent views while conducting the discussion on Day 7 (i.e., Phase I: In-class Peer Discussion), provoking serious verbal conflicts.</td>
<td>- Some students were too shy to record their findings and arguments when conducting the out-of-class enquiry tasks required in Phases III and IV, hindering the effectiveness of the peer-discussion and teacher debriefing conducted on Days 7 and 10 (i.e., Phase I: In-class Peer Discussion and In-class Debriefing).</td>
<td>- Some students did not pay attention to the teacher on Day 1 (i.e., In-class Connection), Day 4 (i.e., In-class Conceptualization), and Day 10 (i.e., In-class Debriefing), and were reluctant to participate in the group discussion on Day 7 (Phase I, In-class Peer Discussion).</td>
</tr>
</tbody>
</table>

**Acknowledgement**

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Online Student-centered Seamless Learning Course under the COVID-19 Pandemic

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Abstract: In this paper, we describe the case study on conducting online student-centered seamless Japanese language and culture learning course under the COVID-19 pandemic in Japan. The Blogger and a chat tool called InCircle were introduced to run an online Japanese language and culture class, which consisted of 7 international students during 2020 spring semester at the university in the western part of Japan. The result of the questionnaire survey implies that the Blogger and InCircle combined language and culture learning class was successful though it has a minor limitation. The use of InCircle as a means of live communication contributed to the successful online class. It would be a useful tool even after the end of COVID-19 pandemic.

Keywords: COVID-19, Japanese language learning, international students, online class, student-centered, seamless learning

1. Introduction

The COVID-19 pandemic has affected various aspects of education in Japan. All the campuses in Japan had been closed after Emergency declaration issued in April, 2020. The university, which the first author belongs to, had decided that all the courses would be held online throughout 2020 spring semester. An online Japanese language and culture course for international students was conducted by the first author. Though the preparation time was not enough, it turned out that class was going well. The rest of this paper refers to how the class was conducted and the result of the questionnaire survey.

2. Backgrounds

2.1 Student-centered seamless learning

The term, “seamless learning” was referred by American College Personnel Association back in 1994. They stressed the importance of linking students’ in-class and out-of-class experiences to create seamless learning and academic success (cited from Wong and Looi, 2011). Besides, student-centered learning has been drawn attention and it is reported that student-centered and small-scale course programs resulted in more academic success than lecture-based course program (Severiens, Meeuwisse & Born, 2015). In addition, numerous publications emphasize the importance of cultural understanding in foreign language learning (Schulz, 2007). Taking those things into account, the learning scenario was designed to realize a student-centered, seamless learning class emphasizing the learning of the cultural background of the language.

2.2 Blogger and InCircle combined language and culture learning class

2.2.1 Google Blogger

The blog was created for the students to upload and share what they have learned during their out-of-class learning. They could learn their classmates’ knowledge on the Blog. The teacher picked out some topics and deepened the knowledge using InCircle to carry out seamless learning where students’ out-of-class learning is entwined with their in-class learning.
2.2.2 *InCircle*

InCircle a, chat tool, is a product developed by AOS Mobile Inc., Tokyo, Japan with our second author joining this project as a chief software architect. Teacher created accounts for their students and made a group for class in advance. This tool was used mainly during real class time which was scheduled to be held on Tuesday, the 4th period.

3. Evaluation

3.1 The target class

The class was targeted for international students who were studying at the university in the western part of Japan. It consisted of 7 students (2 French, 1 Germans, 1 Finnish, 1 Greek, 1 Indonesian, 1 Uzbek). All the students' target language was Japanese. They were all owners of smartphones and PCs, so there was no difficulty for them to take online courses.

3.2 Learning Scenario

Figure 1 shows how out-of-class learning is entwined with in-class learning. Student A learned a Japanese word, "鳥居 (torii=gate) " during her out-of-class learning and uploaded to Blog B. Students were supposed to do it as one of their home assignments. The teacher told them that the number of uploads affected their grades. The teacher picked out some useful topics to deepen their knowledge during class. She picked out "鳥居 (torii=gate) ", which takes an important role in Japanese culture and explained more deeply about it on InCircle during class. The students autonomous out-of-class learning was entwined with their in-class learning. That way student-centered seamless language and culture learning was carried out.

![Figure 1. Student-centered seamless learning.](image)

<table>
<thead>
<tr>
<th>Questions</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q.1 Was it fun to learn Japanese language and culture with our class Blog?</td>
<td>4.6</td>
<td>0.89</td>
</tr>
<tr>
<td>Q.2 Was it easy for you to handle Blog?</td>
<td>3.2</td>
<td>1.64</td>
</tr>
<tr>
<td>Q.3 Please rate its interface of Blog.</td>
<td>3.6</td>
<td>0.89</td>
</tr>
<tr>
<td>Q.4 You also learned Japanese language and culture via InCircle. Was it helpful?</td>
<td>4.6</td>
<td>0.89</td>
</tr>
<tr>
<td>Q.5 Was it easy for you to handle InCircle?</td>
<td>4.6</td>
<td>0.55</td>
</tr>
<tr>
<td>Q.6 Was it fun to learn Japanese language and culture via InCircle?</td>
<td>4.6</td>
<td>0.55</td>
</tr>
<tr>
<td>Q.7 Please rate its interface of InCircle.</td>
<td>4.6</td>
<td>0.55</td>
</tr>
</tbody>
</table>

Table 1. The results of the 5-point-scale questionnaire

3.3 Results

3.3.1 The Questionnaire Results

Table 1 shows the results of the five-point-scale-questionnaire on the usability of Blogger and InCircle, which was conducted at the end of the phase. The higher score, 4.6 was given when they were asked about InCircle (Q.4,5,6,7) than when asked about Blogger, which was created to carry out student-centered seamless learning. Student #3 felt Blogger was fussy and #5 felt it was confusing (cf. Table 2), but all the students' comments were positive on InCircle. Table 3 shows their comments on the merits and demerits of online class.

Table 2. The students’ free comments on InCircle and Blogger
Although it was unusual in the beginning, I think it has its benefits if students are frequently exposed to its content. It was useful to talk about topics. It is also nice that one can always go back and check the chat-log for information again.

It was really great learning with blog, since everything is structured and it is divided per date of post. However, it will be better if you give bullets for each point you want to announce since it's a bit confusing.

It's a simple messaging app. I like simple.

I used to study in traditional way with books, Blog was new for me.

It can be confusing sometimes, but it is very practical.

Table 3. The students’ free comments on the merits and demerits of online class

<table>
<thead>
<tr>
<th>Merits</th>
<th>Demerits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student #1</td>
<td>It is quite convenient to be able to access and work on class related things from anywhere.</td>
</tr>
<tr>
<td>It might be easier to get distracted.</td>
<td>It can create a lesser sense of urgency to complete assignments in time and result in procrastination.</td>
</tr>
<tr>
<td>Student #2</td>
<td>I think no, there is still benefit pushing for studying even in online method.</td>
</tr>
<tr>
<td>No, the important thing is knowledge learned, but not the method</td>
<td></td>
</tr>
<tr>
<td>Student #3</td>
<td>we can do it anywhere, however we do not get the chance to presentate and interact face to face.</td>
</tr>
<tr>
<td>A lot of people can skip classes whenever they want!</td>
<td></td>
</tr>
<tr>
<td>Student #4</td>
<td>There is no point to conducting this class in person, because we use computers anyway.</td>
</tr>
<tr>
<td>Lack of body language</td>
<td></td>
</tr>
<tr>
<td>Student #5</td>
<td>Easy access, more private, information and knowledge gathered in a place.</td>
</tr>
<tr>
<td>Less personal</td>
<td></td>
</tr>
</tbody>
</table>

4. Discussion and Conclusion

Blogger was created to entwine their out-of-class learning with their in-class learning. However the questionnaire results revealed that Blogger site sometimes confused in terms of its interface. As Student #3 in Table 2 suggested, bullets points would help them look more organized. The use of InCircle as a communication tool contributed to the successful online class from the following reasons. It made it possible to conduct real-time online class for those who could attend class real-time as well as for those who could not attend class real-time. As Student #1 commented, "It is also nice that one can always go back and check the chat-log for information again" and Student #5 commented, "The best part is that you can always log in and read everything again in case you forgot." (Table 2), it contributed to the learning reinforcement. As Student #2 commented: "Incircle is really interactive and fun!" (Table 2), real-time attending students interacted actively with other real-time attending students, which was in fact difficult to do the same thing in the face-to-face class since some students hesitate to express themselves in front of a large audience. On the other hand, As Student #1 commented in Table 3 "It might be easier to get distracted.", there were some limitations such as a difficulty for the teacher to grasp what they were actually doing in a virtual class and handfuls for the teacher to handle InCircle where students reacted different topics at the same time. With such limitations, it was still a very supportive tool to conduct real-time online class. As a conclusion, it would be a useful tool even after the end of COVID-19 pandemic.

Acknowledgements

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References


Enhancing EFL students’ speaking performance in university English courses through video peer feedback

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Abstract: This work in progress used video peer feedback to explore college students’ speaking performance in oral presentations. Based on a pre-test, a sample of 51 college students studying English as a foreign language (EFL) was divided into control and experimental groups, with 23 and 28 students in each group, respectively. Both groupings were further divided into groups of two or three students to develop oral presentations. Data collection consisted of pre- and post-tests and evaluations of the group project presentations. The control and experimental groups uploaded their projects to an online learning platform and gave brief presentations. The two teachers then evaluated students’ projects. The difference between the control and experimental groups was that in addition to written feedback, the latter recorded video-mediated oral feedback, providing verbal comments regarding other teams’ oral presentations. The results of this study indicated that the students in the experimental group positively perceived the learning process in the oral presentation exercise and performed better than those in the control group. They offered encouraging and immediate feedback to their peers and perceived peers’ annotations, which enhanced their oral presentations in terms of fluency, content, organization, and delivery. This study suggests that EFL college students can use the video peer feedback to improve their engagement to learn during oral presentation exercises.

Keywords: English as a foreign language, video peer feedback, technology-enhanced language learning

1. Introduction

Students at technical universities need support to develop their English speaking skills, since their English proficiency tends to be relatively poor. The contribution of this study is the embedding of online community-based flipped learning into Taiwanese Culture in English courses, cultivating students’ ability to use simple English to introduce their hometowns and compare them with foreign cultures. Based on Lin & Hwang (2018), this research sought to explore factors affecting EFL students’ oral performance and determine whether video-based peer feedback would have a significant impact on students’ speaking performance and serve as a useful application of technology in the process of learning English.

2. Literature Review

Peer feedback is a learning activity that requires students to provide and receive reactions to and from peers working on the same assignment, helping them to improve their learning performance (Gielen, Peeters, Dochy, Onghena, & Struyven, 2010). Feedback can be in different forms, including ratings and comments made according to scoring criteria. Previous studies have shown that peer assessment helps students to understand teachers’ grading criteria and expectations regarding assignments, enhancing their learning outcomes (Hsia et al., 2015; Lai & Hwang, 2015). Hsia et al. (2015) found that web-based peer assessment approach could improve students' learning performance, self-efficacy and motivation in dance courses. Students felt confident enough to receive and respond to peer feedback. It
was also found that the peer assessment ratings were highly correlated with the teachers’ ratings for every criteria item; furthermore, students were able to evaluate peers’ assignments and revise their own work based on peers’ comments.

Integrating technology into English learning helps teachers guide students to cultivate their language skills through real-life scenarios and meaningful learning experiences (Angelova & Zhao, 2016; Wu, Yen, & Marek, 2011). Overall, teachers teach topics ranging from the familiar to the unfamiliar, moving step by step. Learners rely on established schematic knowledge and the scaffolding of new systemic knowledge when engaging in English learning.

3. Methodology

Research Question

The research question was as follows: Can the video constructive peer feedback enhance students’ speaking performance more than conventional video-based learning?

Participants

Two Taiwanese culture in English classes at a technological university were the subjects of this experiment, a total of 51 students. Students were 20-22 years of age and were formed into groups of two or three. The control group was comprised of 23 participants. The experimental group, 28 students in total, used the cloud-based collaborative learning platform 1know for online community-based flipping learning. The same instructor taught both groups of students. The experimental group applied constructive peer feedback via video. The 23 students in the control group were taught using the conventional approach.

Collaborative learning tool

The learning management platform, 1know, was adopted for students to: (a) view other team’s presentation videos, (b) write comments, and (c) read peers’ comments. Each group developed a PowerPoint presentation that contained descriptions of their hometown as their group project. Both classes spent 40 minutes per session working together for six weeks. Both groups discussed and edited the files via google slides. After six weeks, participants uploaded their projects and images to the 1know platform and made oral presentations for their final projects. Two experienced college English teachers then evaluated the group projects.

Measurement tool

The scoring rubric of speaking performance was developed based on the measure proposed by Lin & Hwang (2018) and Chen & Hwang (2020) and revised by two senior teachers of English. The rubric consisted of four categories: fluency, content, organization, and delivery. For each item, a 5-point scheme was used to rate the students’ speaking performance, with 1 indicating poor and 5 indicating excellent. Two teachers were asked to rate the students’ performances. The average correlation coefficients of the ratings given for each item by the raters were then determined. Pearson’s correlation was 0.68, indicating that the consistency of the raters’ ratings was acceptable.

Procedure

The Taiwanese culture in English course was held once a week for 100 minutes. Both groups of students received traditional teaching in English on the Taiwanese culture for the first four weeks. They were then given a pre-test and pre-questionnaire on speaking performance and classroom engagement. Each week, the two groups of students were scheduled to complete the learning sheet in class, summarizing what they had learned from the instructional videos posted on the 1know platform. The in-class activities for the two groups were identical. The experiment lasted eight weeks, with 100 minutes of class per week. The students in both groups then uploaded their PowerPoint presentations to the 1know platform. Also, the instructor went over the main structures of each unit with both the experimental and control groups, employing slide presentations, audio, and videos tools. Then learners participated in video instruction, with the experimental group using the video-based constructive peer feedback and the control group learning through digital slide presentations. While groups were making oral presentations, other students did peer evaluation via Zuvio. After the teaching activity, all participants were required
to complete a posttest on speaking skills and the questionnaires on classroom engagement.

4. Results & Conclusion

Overall, twenty-eight participants from the experimental group made satisfactory progress, with significant differences ($p=0.038<.05$). The survey items reached a Cronbach's $\alpha$ value of .78. This preliminary work used the $Iknow$ platform, which allows students to upload group PowerPoint projects, record group oral presentations, and further record video-mediated oral feedback in response to other teams' oral presentations. It sought to explore the ability via Zuvio to support peer review. This research, a work in progress, identified the effectiveness of using the $Iknow$ platform. In response to the open-ended questions on the survey, students reported that they enjoyed using $Iknow$ to work on their group projects and interact with other groups. This was especially true for the experimental group, who used $Iknow$ as the peer review platform. Through the post-open-ended questionnaire, students expressed positive reactions to edit their projects with their peers, especially because they could provide instant feedback. They felt that interacting while working on the group project was useful and educational. The result was that technology was integrated into the oral training activity, allowing students to learn from one another and their own perspective, comparing it to foreign cultures.

Acknowledgements
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References


Identifying effective cohesive features for task classification in integrated reading-writing tasks

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Abstract: Many language proficiency assessments have begun to include integrated writing tasks, which require test takers to read and/or listen to the passage and write a response based on the information in the passage. Especially in the research of integrated reading-writing tasks, linguistic features related to cohesion have been seen as indicators of the writing response because it has a relationship with both reading and writing skills. In this study, an integrated reading-writing task is conducted on Japanese English as a Foreign Language (EFL) students. By using machine learning methods, we investigate the relationship between the cohesiveness of the source text and the use of cohesive devices in writing responses in the task. The results of Decision Tree and Random Forest show some significant cohesive devices for the classification of the task. In future research, we will closely look into the linguistic features of each writing response and participants’ writing strategy use in the task. It will provide important implications for increasing the construct validity of integrated reading-writing tasks and writing pedagogy.

Keywords: Learning analytics, Japanese EFL learners, Integrated reading-writing tasks, Cohesion, Decision Tree, Random Forest

1. Introduction

Integrated writing tasks, which require test takers to write an essay response based on information from reading and/or listening passage, has been used in many language proficiency assessments (Gebril & Plakans, 2009; Guo, Crossley, & McNamara, 2013). These tasks have been considered to have positive effects on language teaching and learning because they model the tasks encountered in authentic contexts in academic settings. (Cumming, Kantor, Baba, Erdosy, Eouanzoui, & Janmes, 2005).

Several studies on integrated writing tasks have focused on the linguistic features of task responses (Guo et al., 2013; Tywoniw & Crossley, 2019), and cohesion has been seen as one of the important features. It “refers to relations of meaning that exist within the text” (Halliday & Hassan, 1976; p. 4) and helps the reader to make connections between ideas in the text.

Especially in the assessment of integrated reading-writing tasks, cohesive features can be important indicators of test-takers’ performances because it strongly relates to both reading and writing skills. Some studies have explored the relationship between the cohesive features of writing responses and task scores. However, there are a few studies that focus on the use and effects of cohesive devices in the reading passage, or the source text, and the responses.

This study aims to investigate the relationship between the degree of cohesiveness in the source text and the use of cohesive devices in writing responses in an integrated reading-writing task. An automated assessing tool of cohesive features was introduced, and data were analyzed with machine learning methods.
2. Method

2.1 Purpose

The research question investigated in this study is given below.

Which cohesive devices in responses of the integrated reading-writing task are significant in the classification of cohesiveness of the source text?

2.2 An Integrated Reading-Writing Task

An integrated reading-writing task was conducted on 90 Japanese EFL students in a university in Ibaraki prefecture, Japan. The corpus data used in the analysis include 152 writing responses in the task. The corpus consists of two materials, and each one contains the source text with high/low cohesion.

Table 1. Description of Corpus data

<table>
<thead>
<tr>
<th>Prompt</th>
<th>Cohesion of source text</th>
<th>Number of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gap year</td>
<td>High</td>
<td>38</td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td>38</td>
</tr>
<tr>
<td>Material 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Virtual friend</td>
<td>High</td>
<td>38</td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td>38</td>
</tr>
</tbody>
</table>

2.3 Linguistic Analysis

Cohesive devices in all essays were measured by using the Tool for the Automatic Analysis of Cohesion (TAACO; Crossley, et al., 2016). TAACO is a free automated natural language processing tool and incorporates over 150 cohesive devices.

2.4 Statistical Analysis

Cohesive devices used in the analysis were first assessed to ensure that they did not strongly correlate with each other. The features which strongly correlated to others (Spearman’s r > .80) were not included in the later analysis. To examine cohesive features that were significant in the classification for the cohesiveness of source texts, Decision Tree and the Random Forest were adopted with Python 3.7.6.

3. Results

In the analysis of Material 1, 76 cohesive devices were included, and Figure 1 showed the results of Decision Tree. The result of Decision Tree and feature importance in Random Forest indicated that the use of connectives across an entire text and the overlapped use of verbs and function words between adjacent paragraphs played an important role in classification.

In the analysis of Material 2, 84 cohesive devices were included, and Figure 2 showed the results of Decision Tree. As the result of Decision Tree and feature importance in Random Forest, the type-token ratio of adverbs across an entire text and the overlapped use of adjectives between adjacent sentences played an important role in classification.

The final classification accuracy of each classifier is shown in Table 2 below.
Table 2. Classifiers used and the final classification accuracy

<table>
<thead>
<tr>
<th></th>
<th>Decision tree classifier</th>
<th>Random forest classifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form 1</td>
<td>59.0 %</td>
<td>72.7 %</td>
</tr>
<tr>
<td>Form 2</td>
<td>59.0 %</td>
<td>59.0 %</td>
</tr>
</tbody>
</table>

4. Discussion and Future Research

The result in this study implies that there were some cohesive devices which were significant for the classification of the task based on the cohesiveness of source texts. In Material 1, participants who read the high cohesive passage wrote responses which had a fewer number of connectives, and a fewer number of overlapped adjectives and verbs than those read the low cohesive text. In Material 2, participants who read the high cohesive passage wrote responses that had a variety of adverbs and a fewer number of overlapped adjectives than those read the low cohesive source text.

In future research, we will closely look into the linguistic features of each writing response and investigate the qualitative relationship between the cohesiveness of the source text and the use of cohesive devices in the response. Furthermore, participants’ writing strategy use in the task will be included in the future analysis to examine how their psychological factors influence the writing performance in the integrated reading-writing task. It will provide important implications for increasing...
the construct validity of the task and writing pedagogy.

References


Cumming, A., Kantor, R., Baba, K., Erdosy, U., Eouanzou, K., & James, M. (2005). Differences in written discourse in independent and integrated prototype tasks for next generation TOEFL. Assessing Writing, 10(1), 5–43.


Automatic identification of tense and grammatical meaning in context

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Abstract: This paper describes the development and evaluation of the Tense and Meaning Identifier (version 2.0). This prototype pedagogic tool categorizes finite verb groups in simple sentences into one of twelve grammatical tenses, and categorizes the verb into classes, such as stative and dynamic, and where applicable subclasses, such as punctual or durative. Using the results of the tense and verb class categorization, the grammatical meaning in context is predicted. Drawing on the Natural Language Toolkit, a program was written to classify finite verbs by their tense and aspect. A tailor-made list of verbs and their associated verb classes and subclasses was created by crawling the web and extracting lists from grammar books. The tailor-made lists are stored in a Python dictionary. A tense-class Python dictionary was also created to look up the corresponding meaning in context. A web app with a submission form was created to enable online submissions and show the tense, verb class and meaning in context for simple declarative sentences. The tense identifier is able to relatively accurately (69% to 100%) identify tenses, but further development is necessary to reduce false positive results. The limitations of this prototype are detailed and suggestions for further work provided.

Keywords: grammatical meaning, tense identification, aspect identification, NLTK

1. Introduction

Learners of English language dedicate many hours to understanding the complex tense and aspect system. Grammatical aspect is inextricably intertwined with lexical aspect. One realization of this association is that stative verbs do not normally take progressive forms. The combination of tense and verb class can be used to predict the meaning of the grammatical tense in context. For example, the most common grammatical meaning of past progressive used with durative verbs (e.g. walking) is to describe an action in progress at a point or period in the past as illustrated in the example: I was walking when I tripped.

Should language learners wish to know the lexical meaning of a verb, they can look it up in an online dictionary. However, should they wish to know the grammatical meaning of a verb in context, there is currently no way to look it up. In fact, there is no online tool that can display the tense and aspect, or even verb class on demand. The Tense and Meaning Identifier (version 2.0) aims to fill this niche by identifying and displaying the tense, verb class and grammatical meaning in context for finite verb groups in simple declarative statements.

2. Background

Tense, strictly speaking, refers to either the past or the present. However, textbooks also include future, which to grammarians is usually considered as an aspect, due to its inherent subjectivity. There are multiple ways to categorize verb forms, but the twelve-tense system is one of the most popular. It should be noted that the name of the tense refers to the type of words in the verb form and not necessarily the time zone that the tense is used to refer to. For example, present simple tense can be used to refer to the past or future as shown in the following examples:

- A man walks into a bar and says “ouch”. [referring to past]
- I can do it tomorrow. [referring to future]
Textbooks designed to help non-native speakers of English make extensive use of the twelve verb forms or grammatical tenses (Yule, 1998, p.54). The twelve grammatical tenses, exemplified in Table 1, combine tense, aspect and mood to convey 26 common grammatical meanings in context. These 26 categories can be more finely subdivided into 45 categories (Quirk and Greenbaum, 1993).

Table 1. Table showing the dynamic verb swim in twelve grammatical tenses

<table>
<thead>
<tr>
<th>Past</th>
<th>Present</th>
<th>Future</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple</td>
<td>swam</td>
<td>swim</td>
</tr>
<tr>
<td>Progressive</td>
<td>(was</td>
<td>ere) swimming</td>
</tr>
<tr>
<td>Perfect simple</td>
<td>had swum</td>
<td>ha(s</td>
</tr>
<tr>
<td>Perfect progressive</td>
<td>had been swimming</td>
<td>ha(s</td>
</tr>
</tbody>
</table>

Figure 1 exemplifies the process to determine tense and meaning in context. Users input a sentence. Using the part-of-speech (POS) tags, the verb group is identified. The verb tense and the verb class are matched. The grammatical (and not the lexical) meaning is then determined.

Sentence: *I was driving* my car then.
Expected POS tags: VBD + VBG
Verb group: was driving
Verb tense: past progressive
Verb class: dynamic, durative
Grammatical meaning: an action in progress at an earlier time

3. Development

The server-side of the system architecture uses scripts created in Python to identify tense, determine verb class, and predict the grammatical meaning in context while the client-side is a web app with a simple submission form.

A program in Python that utilizes tokenization and part-of-speech (POS) tagging function of the Natural Language Toolkit (NLTK) (Loper and Bird, 2002, Bird, Loper, and Klein, 2009) was created. The Penn Treebank tag set (Marcus, Santorini, and Marcinkiewicz, 1993) was used. The verb group can be identified by the POS tags, and regular expressions can then used to match particular permutations of parts of speech (POS) and word forms to identify the grammatical tense of the verb group.

A Python dictionary of keys (verbs) and values (classes) was created by collating lists of verbs collected and harvested from various language learning resources. As the largest class of verbs is the durative subclass of dynamic verbs, this is assigned as default. The dictionary items then override this assignment. Polysemy causes issues, since some verbs are stative with one lexical meaning but dynamic with another meaning.

A matrix of the twelve grammatical tenses and two main classes (stative and dynamic) was created. This resulted in 24 cells; however, stative verbs were not used in four cells. Following this step, the possibility of different meanings for the five subclasses of verbs was considered for each of the cells. When a change of meaning was discovered while testing prototypical verbs in each of these classes, these subclasses were appended. The final matrix served as the basis of the design of the layout of a Python dictionary that stores the tense-class and meaning in context.

The web app is hosted on Heroku and deployed directly from Github using the Flask framework harnessing WTforms. Figure 2 shows a screenshot of the output of a submission.
4. Evaluation

The accuracy of the tense identification was evaluated using a balanced dataset of 218 simple declarative sentences. The results for the less common tenses, e.g. future perfect progressive were excellent, but the results for the most common tenses ranged from around 70% to 90%.

![Grammatical Tense Meaning In Context](image)

*Figure 2. Output for simple sentence showing tense, class and meaning*

<table>
<thead>
<tr>
<th></th>
<th>Past</th>
<th>Present</th>
<th>Future</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple</td>
<td>88.89%</td>
<td>88.00%</td>
<td>72.72%</td>
</tr>
<tr>
<td>Progressive</td>
<td>100.00%</td>
<td>100.00%</td>
<td>69.23%</td>
</tr>
<tr>
<td>Perfect simple</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>Perfect progressive</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

The current caveats with this system include (1) part-of-speech tagging errors resulting in misidentification of the finite verb, (2) the lack of a comprehensive dataset for verb classes, (3) the inability to disambiguate between the lexical meanings of polysemic verbs, which in turn affects the ability of the system to determine the grammatical meaning in context. Additional limitations include that (4) only simple declarative sentences are addressed, and (5) just one verb group is processed.

5. Conclusion

To address the limitations of the system the next prototype will use a parse tree that matches the POS tags rather than a series of conditional statements. The verb class dictionary will be replaced by drawing on WordNet to identify supersenses for verbs, one of which is stative. A more finely grained matrix of grammatical meanings in context will be constructed using the 180 permutations of fifteen supersenses and twelve tenses. In addition, the system will be extended to deal with multiple verb groups. The Tense and Meaning Identifier (version 2.0) is available at [https://tense-identifier.herokuapp.com/](https://tense-identifier.herokuapp.com/).

Acknowledgements

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References

Demographic Predictors of Teachers’ Stages of Concern for STEM Education in Hong Kong

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Abstract: This study explored the demographic predictors of teachers’ stages of concern (SoC) for science, technology, engineering, and mathematics (STEM) education in Hong Kong. Results of multiple regression analysis demonstrated that teaching sector and participation in STEM education training predicted four SoC, whereas teaching subject area predicted two SoC. We discussed the significance of these findings by adopting a personalized approach to teacher professional learning.

Keywords: Demographic predictors, stages of concern, STEM teachers, STEM education

1. Introduction

Science, technology, engineering, and mathematics (STEM) education has received increasing attention worldwide; in particular, enhancing the quality of STEM education is a challenge faced by teachers, school leaders, and policymakers. Extensive research has been conducted on supporting STEM teaching and learning through integrated pedagogical practices (Kelley & Knowles, 2016); however, relatively little is known regarding teachers’ concerns about STEM education. This paper reports ongoing research that aims to explore the demographic variables predicting teachers’ stages of concerns (SoC) for STEM education in Hong Kong. We first present the method of our study and then the results based on a territory-wide survey of STEM teachers. Next, we discuss the significance of the findings by adopting a personalized approach to teacher professional learning (Rodman, 2019). As a way forward, we’ll analyze teachers’ responses from the open-ended questions of the survey to help overall interpretation. It is suggested that more studies are needed to understand teachers’ concerns about STEM education in other cultural contexts.

2. Method

2.1 Procedure

Data were collected from STEM teachers in late April 2020. Our original intent was to select regionally representative primary and secondary schools from the main regions of Hong Kong and invite their STEM teachers to respond to an online, self-reported survey. However, classes were suspended because of the impact of the novel coronavirus. By using the school information available from the website of the Committee on Home-School Co-operation (https://chsc.hk/main.php?lang_id=1), we sent emails to all primary (n = 510) and secondary schools (n = 444) in Hong Kong to recruit research participants. International schools were excluded from our study because their curricula are typically different from those of local schools that follow the Hong Kong science, technology, and mathematics education curricula. Additionally, we invited the schools that our investigators knew personally. Finally, we received completed questionnaires from 370 STEM teachers; after invalid questionnaires had been omitted, 331 valid responses were obtained.
2.2 Participants

The participants comprised 132 female and 199 male STEM teachers. This study collected demographic data from these teachers, including their gender, age, teaching experience, class size, highest education level, professional teaching qualifications, school type, school region, teaching sector, teaching subject area, and participation in STEM education training. With the exception of age, teaching experience, and class size, all the variables were categorical and those with more than two levels (school type and school region) were coded into corresponding dummy variables. On average, the STEM teachers were 39 years old, had 15 years of teaching experience, and taught a class size of 29 students. The majority of them had obtained postgraduate degrees (54%) and postgraduate diploma of education for teaching (70%), and they primarily taught in subsidized schools (88%) in the New Territories and the Outlying Islands region in Hong Kong (56%). Most of the participants were secondary school teachers (63%) and taught subjects related to science, technology, and mathematics education (84%). The vast majority of the teachers had received some form of training in STEM education, including workshops, seminars, courses, and field trips (96%).

2.3 Measures

Teachers’ concerns about STEM education were measured with the 19-item SoC questionnaire, using a 5-point Likert scale (Geng, Jong, & Chai, 2019). Readers may refer to their paper for the full set of items. The questionnaire had been validated by STEM teachers in Hong Kong prior to use in this study. The questionnaire targeted the following five SoC: evaluation (3 items), information (5 items), management (4 items), consequence (4 items), and refocusing (3 items). The evaluation items measured the value teachers attach to implementing STEM education in schools. The information items measured teachers’ needs concerning the teaching practice of STEM education and the availability of pedagogical resources. The management items measured teachers’ concerns regarding the practical problems encountered during the delivery of STEM lessons in classrooms. The consequence items measured teachers’ concerns regarding the impact of STEM education on how students learn and how teachers grow professionally. The refocusing items measured teachers’ concerns regarding the development of STEM education in the future. In terms of reliability, Geng et al. (2019) found these five dimensions of SoC to have satisfactory Cronbach’s alpha values ranging from 0.70 to 0.83.

3. Results

Confirmatory factor analysis was conducted on the data collected from the SoC questionnaire to assess the validity of the 5-factor model. The model fit indices suggested an acceptable fit between the model and the data ($\chi^2$/df = 2.391, CFI = 0.954, TLI = 0.945, and RMSEA = 0.065) (Hu & Bentler, 1999). The teachers reported high levels of concern for STEM education, with mean ratings of over 4 for items in all five SoC. Additionally, multiple regression analysis was conducted to evaluate whether the aforementioned demographic variables could significantly predict teachers’ SoC for STEM education. The regression models yielded statistically significant results for four SoC, with the exception of management (see Table 1). Gender and school region were significant predictors of refocusing ($\beta = 0.146, p < 0.05$) and consequence ($\beta = 0.204, p < 0.05$), respectively. Teaching subject area was a significant predictor of both evaluation ($\beta = 0.135, p < 0.05$) and information ($\beta = 0.146, p < 0.05$), indicating that teachers involved in science, technology, and mathematics education demonstrated more concerns in these two stages than teachers involved in nontraditional STEM education areas such as Chinese and English education. Both teaching sector and participation in STEM education training were significant predictors of evaluation, information, consequence, and refocusing, suggesting that primary school STEM teachers expressed more concerns in these four stages than did secondary school STEM teachers. Additionally, STEM teachers who had received training in STEM education expressed more concerns than did those who had never been trained.
Table 1. *Multiple Regression Analysis for Predicting Teachers’ SoC for STEM Education*

<table>
<thead>
<tr>
<th></th>
<th>Evaluation</th>
<th>Information</th>
<th>Consequence</th>
<th>Refocusing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>β</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>0.146*</td>
</tr>
<tr>
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<td>Teaching sector</td>
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Note. *p < 0.05. **p < 0.01. ***p < 0.001. ns: not significant.

4. Discussion and Conclusions

The different concerns, as predicted by different demographic variables, indicate individual differences among STEM teachers. Primary school STEM teachers should urgently be provided with professional learning opportunities that are different from those offered to secondary school STEM teachers (Margot & Kettler, 2019). Similarly, STEM teachers who have received training in STEM education require different kinds of professional learning than the untrained ones. More support should be provided for STEM teachers involved in science, technology, and mathematics education because they show more concerns than teachers involved in nontraditional STEM education areas such as Chinese and English education in the evaluation and information stages. The results from the multiple regression analysis highlight the need to adopt a more personalized approach to professional learning of STEM teachers (Rodman, 2019). Our next step is to analyze teachers’ responses from the open-ended questions of the survey for their concerns about STEM education to help overall interpretation. Also, future research should be conducted to understand teachers’ concerns about STEM education in other cultural contexts.

Acknowledgments

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References

An Investigation of Stag and Hare Hunting Behaviors in a Computer-Supported Collaborative Learning Environment

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Abstract: This study investigated the stag and hare hunting behaviors of students in a computer-supported collaborative learning environment (CSCL). Our initial findings suggest that these behaviors do exist in a CSCL and that these behaviors have distinct characteristics. These behaviors are primarily driven by the personality traits of the students. Mobile CSCL will be improved based on the initial findings of the study. Future research directions and challenges are also discussed in this paper.

Keywords: collaborative learning, mobile games, personality

1. Introduction

Computer-supported collaborative learning (CSCL) is a technology-supported environment that aims to enhance students’ social learning, knowledge sharing, and knowledge creation through increased peer interaction, collaboration, and discussion (Lipponen et al., 2003; Sung, Yang & Lee, 2017; Jeong, Hmelo-Silver, & Jo, 2019). Prior works confirmed the positive effects of CSCL on academic achievements (Sung et al., 2017), cognitive outcomes (e.g., understanding subject concepts), and affective outcomes (e.g., attitudes) (Jeong et al., 2019). Moreover, the impact of CSCL on behavioral engagement (e.g., problem-solving behaviors, individual participation, group discussion, group cohesion) is well-documented (Kapur & Kinzer, 2007; Siqin, Van Aalst, & Chu, 2015; Kwon et al., 2019). However, the stag and hare hunting behaviors in a CSCL environment are relatively unknown. These gaming behaviors are based on Skyrms’ (2001, 2004) discussion of stag hunting behavior proposed by Rousseau. According to this social contract theory, people may choose higher or lower payoffs depending on the risks associated with these choices. This study investigated the stag (i.e., students who choose a faster game setting with higher points and penalties) and hare hunters (i.e., students who chose a slower game setting with lower points and penalties) in the context of a mobile CSCL environment.

2. Research Goals

The goals of this study are threefold. The first goal is to develop a model that could characterize the stag and hare hunting behaviors of students while solving arithmetic problems in Ibigkas! Math (subsequently referred to as the software). The second goal is to develop adaptive software based on the model. Finally, the revised software will be then deployed to test whether it has an impact on students' stag and hare hunting behaviors, and on their mathematics learning.

3. Methodology

Thirty-seven Grade 5 students (25 boys and 12 girls) participated in the study. The average age of the participants is 11 years old. The participants used the software for 15 minutes during their class session. A pretest and posttest were administered to determine their mathematics performance. All interaction...
log files such as difficulty level, types of the problem solved, speed, time spent, number of attempts, correct attempts, and accuracy) were manually collected from the mobile phones. The personality types of the participants were also determined. The participants answered the Big Five Personality Types Test (John & Srivastava, 1999). Mann-Whitney U test, Spearman rho rank correlation, decision tree modeling, and lag sequential analysis (LSA) were employed to analyze the data.

4. Initial Results

It is found that stag hunters have higher game interactions than the hare hunters. However, stag hunters’ interactions are not beneficial to mathematics learning. Decision tree analysis shows that the personality types of the students are the primary factor that could classify students’ stag and hare hunting behaviors. Contrary to the existing literature, students with a neurotic personality type in this study tend to contribute to the welfare of the team and are cautious players. The LSA results suggest that all difficulty levels in addition were the most preferred game setting. It was also found that hare hunters attempt to solve different problems while stag hunters tend to stick to the same type of problem and level of difficulty.

5. Future Plans

Based on the initial results of the study, the software will be modified to make it more adaptive. The revised version will be then deployed to determine its impact on game interactions and mathematics performance of the participants.

6. Challenges and Questions

There are logistics implementation challenges because of the COVID-19 pandemic. Face-to-face experimentation may not be possible because schools shifted to online learning. The influence of the newly developed game on the mathematics performance of the students and the stag and hare hunting behaviors will be further explored. Moreover, investigation of the factors that push students with a neurotic personality to collaborate with their peers is worth-investigating.

Acknowledgements

The author is indebted to Dr. Ma. Mercedes Rodrigo, Dr. Nieva Discipulo, Dr. Ma. Leonila V. Urrea Ellen Tabayan, UE Elementary and Senior High School Laboratory School staff, research assistants, and all participants of the study. This paper is funded by the DOST-ERDT.

References


Artificial Intelligence in Education (AIEd)

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Abstract: The use of Artificial Intelligence (AI) in education is no longer science fiction but becoming a reality in these unprecedented times of dynamic changes. This field encompasses a wide range of techniques, algorithms, and solutions that may resolve current predicaments and problems in today’s classroom. This paper discusses how AI that is supporting the existing world can be extended into the fields of education and addresses the existing challenges of using AI within classrooms across Singapore.

Keywords: Artificial intelligence, education, analytics, future challenges

1. Introduction

We currently live in a volatile, uncertain, complex, and ambiguous (VUCA; Bennett & Lemoine, 2014) world, where a state of flux has replaced the sense of stability, certainty, and familiarity that people are used to. Technology and change are rapid and unpredictable, disruptive in almost every industry and country. In a world that is now supported by Artificial Intelligence (AI), there is a need to be empowered by an understanding of what AI in education is, what it can deliver, and how it goes about doing that (Luckin, Holmes, Griffiths, & Forcier, 2016).

Some existing empirical studies (e.g., Hao, 2019) have shown that as much as AI is currently being touted to be a worthy educational tool that can provide personalized learning at scale, there was also equal amounts of fear that it could backfire and entrench a global trend towards standardization of teaching and learning, thus leaving the next generation ill-prepared for a dynamic and changing world. Certain studies (e.g., Guilherme, 2019) have also examined the use of thought experiments to predict if the development of AI could potentially replace human teachers in the classroom.

The approach of this study is, however, not to introduce global standards and definitely not to replace teachers. We seek to create a future where teachers can utilize AI to transform their current roles as facilitators and providers of content, into co-constructors of knowledge with students who can take ownership of their learning processes. For example, AI can be used to provide collaborative learning support (Magnisalis, Demetriadis, & Karakostas, 2011) with potential to extend possibilities of teaching, learning, and research (Popenici & Kerr, 2017), so as to ensure resources are more effectively utilized and student’s expertise can be augmented by AI.

2. Research objectives

This study seeks to address two existing challenges. First, by understanding and acknowledging the advantages and limitations of existing AI approaches and techniques, we could then identify potential knowledge gaps and deficits in expertise that are necessary to support the development and implementation of AI in education. This requires existing students to possess attributes akin to 21st century competencies not limited to creativity, critical thinking, collaboration (Tan, Choo, Kang, & Liem, 2017), in order for students to be active designers and productive contributors to local and global futures, be it economic, social, or cultural in nature. Second, apart from identifying a pool of competent students and future workers, teachers looking to utilize and implement AI-enabled tools also require support with integrating them into teaching practices. This includes consulting teachers during the design cycles of the tool, balancing personal and institution-wide pedagogic issues (e.g., reluctance to change based on experience and groupthink) with benefits from the tool, and feasible implementation of the tool in schools with considerations of local context and practice.
3. Methodology and building on current work

The interdisciplinary nature of this field often gathers wide-ranging definitions from experts with their own perspectives and terminologies. This study follows the definitions by Russell and Norvig (2020), that AI includes multiple aspects, such as problem solving, representation and reasoning of knowledge, machine learning, and techniques for designing and developing of intelligent agents.

This study then narrows the scope of these aspects to the design and implementation of AI-related tools within the field of education. Data would be collected from pilot trials in schools across Singapore and multimodal sensors will be used, such as audio, video, physiological and online detection mechanisms (e.g., online trackers), to record multimodal data in classroom lessons. Two case studies are currently identified to integrate the use of AI and analytics in education. The first case study will investigate students’ collaborative processes related to knowledge building in the classroom, sifting out possible traits of students that allow them to be competent thinkers and learners. The second case study is related to teaching analytics, where the teachers’ attention and physical locations in the classrooms would be tracked and analyzed to benefit their teaching practice. In both case studies, the intention was to implement unsupervised learning to draw insights from the unlabeled data, using techniques and algorithms such as k-Means clustering and Hidden Markov Models (HMM) to determine clusters of potentially meaningful data and recover sequences of states. Both case studies will also be built on ongoing work (Lee & Tan, 2017; Lee, Tan, & Tan, 2019) that provides an existing and appropriate framework for the respective case studies. It would be prudent to continue working on these frameworks, especially when it can be further scaled with nascent interest from local participants.

4. Future challenges

The implementation of AI in education has far-flung consequences, including considerations about ethics and equality of access across genders, age, and geographical borders. In addition to these considerations, another major concern would be to ensure that subsequent studies should attempt to avoid unintentional bias during data collection and processing, by leveraging on emergent technologies (e.g., Internet of Things and ambient smart sensors) to gain higher specificity of classroom analysis in a least intrusive manner.

References

Using MALL to explore Language Comprehension of Non-native Speakers

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Abstract: The Philippines has a bilingual education policy that ensures the development of language literacy in its national language, Filipino, and the global language, English. However, being a linguistically diverse country, most of the population in the central and southern islands are non-native Filipino speakers and expressed that they are not comfortable using the national language and have difficulty using English as well. This study aims to explore Filipino and English comprehension of primary school students whose lingua franca is neither Filipino nor English through mobile-assisted language learning.

Keywords: Mobile-Assisted Language Learning, Ibigkas!, Learning Likha

1. Introduction

Language is a symbol of national identity and culture. In the Philippines, the 1987 Constitution designated Filipino as the national language. However, the Philippines has a linguistically diverse population with no absolute majority of speakers of any given indigenous language that even the distinction of what Filipino is remains unclear to most citizens. Many Filipino children’s first language is different from the national language which poses an issue for the cultural communities, for whom Filipino is now their second (or even third or fourth) language. Moreover, the Philippines has a Bilingual Education policy that ensures the development of literacy in Filipino and English as essential to matriculate to higher education and secure a professional occupation (Madrunio et al., 2016). In 2018, the Philippine Supreme Court decided to make the Filipino language optional instead of a required course in tertiary level. With this, it is imperative that students attain a certain level of English and Filipino proficiency at the primary or secondary education level. However, results from prior work (Yanagihara, 2007) indicate that students who are non-Filipino speakers were not comfortable using it. This study aims to use Mobile-Assisted Language Learning to investigate the Filipino and English comprehension of primary school students from rural and urban communities whose lingua franca is neither Filipino nor English.

2. Mobile-Assisted Language Learning – Ibigkas! and Learning Likha

Mobile-Assisted Language Learning (MALL) is a specialized field of mobile learning (mLearning) which utilizes mobile technologies so learners can autonomously study a second language as research show that mobile devices can indeed be effective tools for delivering language learning materials to the students (Kukulska-Hulme et al., 2017). In the current situation it also seems an opportune time to integrate MALL into the language curriculum as mobile phones are more common in the households compared to personal computers, hence, it can reach more underserved cultural minority communities.

The mobile games Ibigkas! (English and Filipino versions) and Learning Likha were developed to help improve English and Filipino literacy skills. Ibigkas! is a drill-type game that can be played in single player or multiplayer mode that focuses on word rhymes, synonyms, and antonyms. Learning Likha, is a narrative type game which targets comprehension skills by attention to details through written, oral, and visual language. Both these games were tested on students whose primary language is Filipino (Moreno et al., 2019; Rodrigo et al., 2019).
3. Data Collection

Ibigkas! (English and Filipino versions) and Learning Likha, will be deployed, through remote testing methods, to elementary students (grades 4, 5, and 6) from a rural public school and an urban public school in southern Philippines. The target number of participants will be 15 for each grade level from each school for each game, with a total of 270 participants. At the start of each session, the participants will be given a survey questionnaire that will assess their attitudes towards the Filipino and English usage and access to technology. The survey will adapt the format used in prior work (Moreno et al., 2019; Rodrigo et al., 2019) and will ask the participants to indicate their levels of agreement (strongly disagree to strongly agree) with statements about their attitudes and usage of Filipino and English. The participants will also be given a pre-test in relation to the learning content of the game. After collecting the survey questionnaires, the participants will play Ibigkas! after which they will be asked to answer the Game-Based Learning (GBL) Engagement Metric (Chew, 2017) and the Intrinsic Motivation Inventory (IMI) (Ryan, 1982) to measure their engagement and motivation. The participants will then answer a post-test in relation to the game’s learning outcomes.

4. Analysis

The following data features are expected to be collected: responses to the survey questionnaire on the attitudes towards usage of Filipino and English and access to technology, Filipino and English comprehension scores (pre- and post-test), interaction logs, performance scores, GBL Engagement Metric components, and IMI components. Outliers will be identified and will be excluded from the data for analysis. A regression model will be developed to determine which among the data features will exhibit significant relationships with Filipino and English comprehension of the learners. These data features will include the learner’s attitude towards Filipino and English, game score, tap counts, GBL engagement metric subcomponents, and IMI subcomponents. The relationship between the learner’s attitude towards the usage of the Filipino/English and their GBL engagement subcomponents and IMI subcomponents and the difference between the Filipino/English comprehension, attitude towards the usage of Filipino/English, access to technology, and in-game performance of learners from the rural area and urban area shall be determined. The findings shall give MALL developers and teachers more insights on the challenges of learning the national and global language for non-native speakers.

Acknowledgement

I would like to thank the Ateneo Laboratory for the Learning Sciences, Ateneo de Manila University.

References

Integrating mediation into computerized dynamic assessment of L2 speaking to inform an effective pedagogy

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Abstract: The computerization of dynamic assessment can allow a large number of learners to be assessed simultaneously and produce rich and easily interpretable results. However, its application in second language (L2) speaking is hardly touched upon. This paper proposes an innovative mediation menu to fill this gap. It promises to produce results for both understanding learners’ speaking competence and facilitating classroom teaching.

Keywords: computer-based testing, dynamic assessment, L2 speaking, classroom teaching

1. Introduction

Dynamic assessment (DA) provides an innovative alternative to traditional static assessment. Framed within sociocultural theory (Vygotsky, 1986) that sees an individual’s interaction with more capable others as sources of development, it 1) allows the examiner to provide mediation (assistance) when necessary; 2) promotes learners’ development in the tested area during the assessment; 3) reveals learners’ strengths, weaknesses and learning potential by tracking their responses to external help. Computerized dynamic assessment (C-DA) is its administration on computers. It increases testing efficiency (Poehner & Lantolf, 2013) and can generate insightful quantitative results (Yang & Qian, 2019; Zhang & Lu, 2019) that aids classroom teaching. However, little empirical work explores the use of C-DA in the assessment and instruction of second language (L2) speaking. Also, nearly all available C-DA research in the area of L2 education test learners with close-ended questions and provide standardized mediation (with the exception of Ai, 2017). Researchers (e.g., Poehner, Zhang and Lu, 2015) call for other modes of testing and more flexible and individualized mediation. This current research aims to fill the lacunae discussed above.

2. Research objectives

The work presented here intends to translate C-DA results into effective L2 speaking pedagogy in which collective teaching activities are carried out with individual competence and needs considered and attended to. To achieve this goal, mediation will be integrated into an existing computer-based speaking assessment program for Chinese learners of English to develop a C-DA extension based on it. Then, this study builds on the results generated in C-DA, including learners’ actual (unassisted) performance, mediated (assisted) performance, and learning potential and explores how they can be used to facilitate speaking instruction within the classroom.

3. Methodology

Two research questions guide this study: 1) to what extent can mediation provided in computerized dynamic assessment of L2 speaking improve learners’ performance? 2) to what extent is a C-DA informed pedagogy helpful in L2 speaking teaching? To answer these two questions, a mixed-method study that comprises three phases is devised. Firstly, a small number of learners will be invited for a
focus-group interactionist DA session to pilot all the speaking tasks. The examiner’s interaction with them and their improvement in speaking performance will be analyzed to enable a mediation menu that contains necessary help for completing the speaking tasks. With this menu programmed into C-DA, it fulfills the role of a mediator/teacher, and test-takers can choose from it what suits their problems the best. Next, the C-DA program will be conducted with over 100 learners to examine the possible distinction between their performance before and after the mediation. Lastly, results from C-DA will be used by a teacher to organize tailored teaching.

The two major types of data in this study are: 1) the $p$ value based on a paired-sample t-test, and 2) the teacher’s and students’ written reflections in their working portfolio. To answer the first research question, the $p$ value will be calculated to determine whether the C-DA program with its mediation menu can result in a statistically significant difference between the participants’ L2 speaking performance. To answer the second question, the participating teacher’s and students’ working portfolio will be collected, in which they are prompted to keep a record of their activities in the L2 classroom related to speaking, the relatedness of these activities to C-DA, and their perceptions and experiences of C-DA influences in their classroom instruction.

4. Challenges and questions

There is a particular challenge that lies in the third phase of this study in which how C-DA results can be translated into effective pedagogical measures is investigated. In the current plan, a teacher will receive all the learners’ C-DA scores and profiles. Nevertheless, what this teacher would do with these results is uncontrolled. Therefore, the question lies in to what extent should the researcher be involved in the decision-making of the teacher. To solve this problem, the researcher will provide necessary references regarding C-DA and classroom DA to the teacher and keep a honest record of all the interactions with the teacher to make public all possible influences and informed practices for further examination.

5. Future plan

As a researcher and practitioner in L2 education, I have continuously focused on L2 speech development and corresponding teaching interventions. This project, made possible by the powerful and innovative tool of computerized testing and dynamic assessment, is part of the efforts to bridge L2 speaking testing and teaching. With empirical data gained from this study, in the future, it is hoped that a C-DA L2 learning program can be developed to serve as both a learning tool and research tool. For learners, they operate independently on their devices and mitigate their speaking challenges with computerized mediation. For research, data generated from this program can feed into a critical understanding of learner potential and individual needs.

Acknowledgment

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References


Innovating Pre-service Science Teachers’ Professional Development with Virtual Reality

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Abstract: As the need for authentic experiences has increased in the science education for 21st century learners, there has been more attention placed on the modes of instruction that can supply greater realism and immersion. In this light, the use of virtual reality (VR) has received considerable attention. I aim to conduct design-based research on novel approaches that support the professional development of pre-service science teachers based upon learning theories. I will also conduct experimental studies and case studies in order to have more in-depth investigation of the roles of VR and pedagogical scaffolds on improving the effectiveness of the professional development. Ethnographic or case studies will also be conducted to have a more comprehensive understanding of the pre-service science teachers’ attitudes, perceptions, challenges, and expectations with regard to the VR integrated professional development method.

Keywords: VR, pre-service science teacher, learning theories, professional development

1. Introduction

Due to the implementation of the Next Generation Science Standards (NGSS), there has been an increased focus on the use of technology-integrated learning in the science classroom (Corrigan, 2015). This focus has put forward high demands on science teachers’ capabilities of understanding the complexity of student learning, applying innovative technologies, and using of various instructional approaches (Howard, 2016; Lamb & Etopio, 2020). However, a lot of current professional development programs for science teachers are built around strict standards that would make it difficult for trainees to have personalized guidance they need (Lamb & Etopio, 2019). A lack of practice in real world situations is another limitation (Lamb & Etopio, 2020).

One possible solution is to integrate the Virtual Reality (VR) technology into professional development for pre-service science teachers. VR has been believed to have considerable potential for science learning and teacher preparation (Tondeur et al., 2017). Integrating VR exposures to science classroom could assist in the learning of real world experiences (Starr et al., 2019). Additionally, with the support of VR, pre-service teachers could have opportunities to confirm, extend, or disconfirm their knowledge about how they would react in classroom (Lamb & Etopio, 2020).

However, current research on applying VR in teachers’ professional development typically focuses on creating a simulated class for trainees to perform augmented and active teaching practice. VR’s affordance of improving the understanding of complex scientific knowledge and phenomena was ignored. Additionally, learner theories have not been considered to guide the development of VR environment, especially for pre-service teachers’ professional development. Most studies evaluated the learning and training outcomes only based upon usability-oriented tests. I see them as limitations.

2. Research Agenda

I intend to conduct designed-based research to design a VR integrated professional development method for pre-service science teachers which could not only provide opportunities for pre-service teachers’ instructional practice, but also facilitate their understanding of scientific knowledge and effective science teaching strategies. This innovative VR integrated, learning theories based professional development method could not only provide opportunities for pre-service teachers’ instructional
practice, but also facilitate their understanding of scientific knowledge and effective science teaching strategies. They could also have teaching practice in the virtual class with the scaffolds designed based upon learning theories. Moreover, the pre-service teachers are guided to design their own VR integrated teaching units, and teach with VR in the simulated class under the supervision of their instructors and peers. In the design-based research’s iteration process of designing, implementing, and revising, the final designs of the professional development, together with the scaffolds, will be achieved.

My prospective effort on the innovative professional development method for pre-service science teachers is to have in-depth investigation on its effectiveness. Experimental studies will be conducted to compare pre-service teachers’ learning achievement, professional skills, and teaching performance under the conditions with different scaffolds. Current research on the evaluation of the effectiveness of teachers’ professional development mainly focuses on one-time assessment of trainees’ real-life outcomes, such as the teaching performance, the knowledge of pedagogical theories and science content, or the usability-oriented tests. However, the process in which the trainees’ professional skills develop and their understandings of teaching and learning change is ignored. There is a recent trend in the educational technology research that researchers exhibit a greater interest in participants’ neuropsychological and neurocognitive process, which are viewed to objectively reflect participants’ learning process, and directly affect their real-world outcomes. Based on this trend, I intend to further analyze the pre-service science teachers’ neuropsychological and neurocognitive reactions in the professional development. Data will be collected in the form of the participants’ hemodynamic responses and neurocognitive processing via the 3D body sensory technology and a SensoMotoric Instrument (SMI) Scene Eye Tracker. These data will unpack the pre-service science teachers’ cognitive, motivational, and meta-cognitive conditions and changes during the professional development.

I intend to carry out ethnographic studies or case studies on pre-service science teachers’ attitudes, perceptions, and the reactions with regard to the VR integrated professional development. These studies aim to unpack its impact on pre-service science teachers’ professional development based upon their own experiences. These empirical studies are not only for the proof-of-concept of the findings of the experimental research, but also for informing the pedagogical practice and the designs of the VR integrated professional development with the ultimate aim of nurturing a culture of personalized and active learning. That would help to have a more comprehensive insight into the process of pre-service science teachers’ professional development, their challenges, expectations, and effort on meeting the increasing demands of 21st learners, and their perceived useful support to enhance their professional development in a technology-rich environment.

3. Significance of Research

This research will also shed an insight into the scholarship of teaching and learning, especially in helping teacher educators to identify ways to increase the effectiveness and efficiency of pre-service science teachers’ professional development with the support of innovative technologies, such as VR. It is deemed timely in the transformation age of education.

References

Developing STEM teachers’ TPACK skills through scaffold co-designing activities

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Abstract: This study is to explore whether and how to scaffold co-designing activities between teacher-researcher collaborations in STEM inquiry-based project can transform teacher’s TPACK-related skills. In this study the scaffolding focus on those can external represent students’ learning process, such as collaborative concept mapping tool, thinking mapping tool or argumentative diagram tool. Some recruited STEM teachers will designing and implementing domain-appropriate and skills-building scaffolds in STEM instruction with the guidance of researchers in learning science. During the whole co-design and implemented process, the discourse data, reflective notes data, classroom video data, TPACK questionnaire data and interview data will be collected and analyzed. The study can provide some insight for teacher professional development, but also can lay foundation for the design of learning environment for teacher’s profession development.

Keywords: co-design, scaffolding, Design-Based Implementation Research, TPACK

1. Introduction

STEM education includes problem-based learning that purposefully situates scientific inquiry and the application of mathematics in the context of technological designing/problem solving (Sanders, 2009). Therefore, to promote the effect of STEM education for learners, teacher should equip TPACK-related skills to handle STEM education. However, STEM teachers faced many constraints. Many teachers lacked sufficient professional knowledge or skills about STEM education because they had no enough prior relevant professional or instructional experiences in their practices (Nesmith & Cooper, 2018). On the other hand, positive outcomes of STEM education can only be achieved when teachers integrated scaffoldings to structure the complex learning processes (Kaendler, Wiedmann, Rummel, & Spada, 2015). Instead, teachers often provided students minimal guidance during STEM instruction (Kirschner, Sweller, & Clark, 2006). Considered that little research has been devoted to identifying the supports that teachers need to teach about complex systems in the classroom (Yoon et al., 2017). The study aims to find a way to help teachers in designing and implementing domain-appropriate and skills-building scaffoldings in STEM instruction. It will not only elevate the competences of STEM teachers, but also elevate the quality of STEM education.

2. Theoretical background

Co-design is the kind of work between teachers and researchers to design, implement and evaluate innovative educational experiences to fill local educational needs and also gain some valuable opportunities to reflect and refine their instructional practice (Matuk, Gerard, Lim-Breitbart, & Linn, 2016). Nowadays co-design of innovative learning environments serve as contexts and catalysts for teacher professional development, which can lead to teacher agency, and flexible, adaptive, principled pedagogy (Wong, Gao, Chai, & Chin, 2011). Based on the notion of learning by design, when teachers engaged in design process with the help of researchers, it can help them make intimate connections among content, pedagogy and technology in a collaborative way (Agyei & Voogt, 2012). Moreover, according to social construction theory, co-design between researchers and teachers is a kind of social interaction. It can help teacher gain fresh perspectives and advance both knowledge and action on instruction, but also can prompt them to rethink their practices, and explore, derive and pilot creative alternatives (McKenney, Kali, Markauskaite, & Voogt, 2015). In the context of design scaffoldings to
support STEM education, researcher had much theoretical knowledge of scaffoldings, which should be used to in STEM instruction. While, teachers may did not understand how to integrated scaffoldings in STEM instruction. Therefore, how to enable teacher design scaffoldings during STEM education by co-design is a promising way for professional development. The study intends to examine whether and how the method of co-design of scaffoldings between teacher-researcher collaborations in STEM problem-based project transform teacher’s TPACK.

3. Methodology

Participants include teachers from a public middle school in Eastern China. The research team will work closely with the participating teachers to co-develop STEM curricula for a semester with four steps. In the first step, teacher was introduced to the background information of scaffolding. The next step is to co-design STEM education integrated with scaffoldings. In the third step, teacher will enact their lessons plan in their class. In the four step, teacher will communicate with each other with their reflection during the whole process. After each step, teacher will write reflective notes to recode what they learned and think. Besides, during the whole process, the research team will communicate with each teacher group and provide them some help timely according to their requirement. During the whole co-design and implemented process, the discourse data, reflective notes data, classroom video data, TPACK questionnaire data and interview data will be collected and analyzed.

4. Challenges and Questions

Some context and practical factors may bring some resistances with the collaboration between researchers and teachers. How to make researchers and teachers understanding each other is the tough issue to address. Moreover, different types of data will be collected. How to synthetical analysis those kinds of data to get understanding the development of STEM teachers’ skill is very important. Thirdly, how to get some implication for large scale STEM professional development program show be considered more seriously.

References


Effects of Computational Thinking Competencies on Scientific Argumentation Learning among Secondary School Students

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Abstract: Argumentation in science education has emphasised on the engagement of students in making scientific claims where they communicate with others. The argumentation is a problem-solving process that nurtures students’ higher order thinking (HOT) by encouraging them to think critically and create solutions. Computational thinking (CT) is the competencies integral for successfully solving problems posed in a technology driven teaching and learning context. Teachers need to develop and scaffold the students’ CT competencies to equip them to be future-ready learners. Accordingly, this study will design instructional strategies for teachers to embed CT-integrated instruction within argumentation teaching in the context of Biological science. Subsequently, the development of students’ CT competencies and argumentation performance will be assessed. The five CT dimensions taken into account in this study are abstraction, decomposition, generalisation, algorithmic design and evaluation. As there is a growing trend of integrating CT across various disciplines, problem solving is no longer viewed as a final goal of learning in science. Instead, it is a competence that should be acquired by individuals to apply throughout the acquisition of scientific knowledge.

Keywords: Computational thinking, argumentation, problem solving, higher order thinking

1. Introduction

Argumentation have been advocated as the core practice in science education to develop higher-order thinking (HOT) (Eskin, & Berkiroglu, 2008). The mastery of scientific argumentation competencies nurture students’ HOT such as reasoning abilities and thus facilitating their academic achievements (Heng, Surif, & Seng, 2015). The scientific argumentation is emphasised through the adoption of higher order thinking skills (HOTS), which is reasoning skills in the primary and secondary school curriculum in Malaysia. Reasoning skills is one of the HOTS required in problem solving activities. At this point, Malaysian school-based Science assessments focus more on problem-solving skills and creativity. In solving scientific problems, argumentation require problem solvers to identify different viewpoints, create a reasonable solution supported by data and evidence. Along this line, Computational thinking (CT) embraces HOT, as CT is a problem-solving approach that draws on fundamental Computer Science (CS) concepts to reformulate and solve the problems (Wing, 2006). CT has been integrated into Malaysian school curriculum in January 2017, starting with primary and secondary students. Research highlights that there is a growing need to integrate CT into academic subjects (Yadav, Hong, & Stephenson, 2016). However, there is lack of empirical findings about how CT can be used to improve the science instructions. Hence, this study focuses on developing students’ CT competencies through scientific argumentation.

2. Literature Review

2.1 Higher Order Thinking in Scientific Argumentation
Argumentation is known as a fundamental aspect of science education and has become one of the major objectives in teaching and learning of science (Duschl, Schweingruber, & Shouse, 2007). Recently, the review on the future argumentation research suggested teaching HOT through argumentation (Henderson, McNeill, González-Howard, Close, & Evans 2018). The problem-solving process enhances individuals’ HOTS, such as reasoning skills as they are required to apply and communicate relevant knowledge based on the context. The HOTS can be developed through scientific argumentative practices (Eskin & Berkiroglu, 2008). Nevertheless, very little attention is given to argumentative tasks in the teaching of science in Malaysia (Heng et al., 2015). From 2016 onwards, the primary and secondary school national assessments in Malaysia comprise at least 40% of HOT questions. However, despite the implementation of HOT development from primary to secondary school level, most Malaysian students are still facing difficulties in comprehending the science content (Academy of Sciences Malaysia, 2018). Thus, more efforts in polishing teachers’ instructional practices is needed to improve students’ scientific argumentation through enhancing HOTS (Ping, 2019). The teachers play a critical role in deciding the critical aspects of the learning and how to make learning visible for students (Voon, Wong, Looi and Chen, 2020).

2.2 Integration of Computational Thinking Competencies into Argumentation Learning

Past research has indicated that CT can be used as a means to improve problem solving skills (Wing, 2006). CT fits in the framework of competencies from the perspective of cognitive dispositions as described by Klieme, Hartig and Rauch (2008). Acquisition of CT can be accomplished by gaining experience from relevant context of demand, it may be affected by external interventions and can be enhanced by continuous practices to build the expertise in a particular domain. Based on the studies conducted by Korkmaz and colleagues (2017), the five CT competencies which were widely-accepted by the International Society for Technology in Education (ISTE), Computer Science Teachers Association (CSTA), and US National Science Foundation (NSF) are described in detailed as: (1) critical thinking is the ability to analyse and make assessment-oriented judgments that lead to decision making; (2) problem solving refers the ability to sustain in investigative processes by generating solutions; (3) algorithmic thinking means the ability to think in a detailed way by placing the proceedings in sequence to produce a solution; (4) creativity is the ability to develop genuine ideas with the combination of existing ideas and new ideas through critical thinking and problem-solving; (5) cooperativity refers to the ability to help each other in learning with different methods in accordance with a common purpose.

2.2.1 Computational Thinking Dimensions

Research shows that the integration of CT into science learning has the potential to help students learn science contents and science practices (Wing, 2008). In this study, CT will be integrated into the topic of Human Reproduction in the science curriculum as many misconceptions have been consistently identified globally (Sirovina, & Kovačević, 2019). Given the pervasiveness of CT in STEM, this new competence is a foundational competency for being successful in STEM work (Wing, 2010). However, CT is relatively new to the field of science education (Peel, Sadler, & Friedrichsen 2019). There were many interventions conducted in the programming context but limited empirical studies focusing on CT learning and science learning (Kalelioğlu, 2018). Hence, there is a clear need for empirical studies supporting the integration of CT and science, especially connecting to science learning outcomes (Peel et al., 2019). Therefore, this study intends to investigate the effects of CT competencies on students’ argumentation performance. This study will design instructional practices to develop HOTS by integrating five CT dimensions into scientific argumentation: (1) abstraction requires individuals to identify the most important aspects of a problem; (2) problem decomposition is to break down problems into smaller and more manageable parts, then focusing on solving each part of problem; (3) algorithmic design focuses on creating step-by-step processes to complete a task or solve a problem; (4) evaluation refers to the identifying, judging the possible solutions and applying the best solution, improving the solution to be applied in other situations; (5) generalisation means taking a solution (or part of a solution) to a problem and generalising it so it can be applied to similar problems.
3. Research Objective

This study aims to investigate the effects of CT competencies on argumentation learning among secondary school students. It also proposes the integration of CT dimensions into instructional practices to improve students’ scientific argumentation learning: first by integrating five CT dimensions into lesson plans to develop students’ CT competencies; second by evaluating the effect of CT competencies on their scientific argumentation performance.

3.1 Theoretical Framework

This study will employ the interactive constructivism founded by Reich (2007) as the theoretical framework to examine the effects of CT in supporting teachers’ instructional design of spoken and written argumentation. The interactive constructivism comprises the features of radical constructivism (Von Glasersfeld, 1989) and social constructivism (Vygotsky, 1978). The synthesis of radical and social constructivists stated that knowledge is self-constructed and socially mediated (Tobin & Tippins, 1993). The theoretical framework asserts that learning has both public and private landscapes. The public landscape focuses on active knowledge construction in a social environment whereas private landscape of learning occurs through individual’s learning reflection (Chen, 2011).

3.2 Research Question

This study examines the effectiveness of the CT-integrated instruction in argumentation, particularly focusing on (1) students who are taking and those who are not taking CS subject; (2) students with high and low academic performance. The following research questions guide this study:

RQ 1. Is there a significant difference in scientific argumentation scores between academically high and low students from CS group in applying the five CT-dimensions?
RQ 2. Is there a significant difference in scientific argumentation scores between academically high and low students from non-CS group in applying the five CT-dimensions?
RQ 3. Is there a significant difference in scientific argumentation scores between the CS and non-CS groups in applying the five CT-dimensions?
RQ 4. Is there a significant difference in scientific argumentation scores between students with high and low levels of CT competencies among academically high and low students in CS and non-CS groups?

4. Research Methodology

To answer the aforesaid research questions, this study employs a factorial design to investigate the effect of CT-integrated instruction in Science lessons. The study adapted Science Talk Writing Heuristic (STWH) approach developed by Chen (2019). To build upon STWH approach, this study emphasises the scientific problem solving by integrating CT dimensions into argumentation, known as CT-argumentation (CTA). The teacher and student templates will be given as a guideline before the intervention. This study adopts the Computational Thinking Scale (CTS) developed by Korkmaz and colleagues (2017) to measure the five CT competencies. A pilot study will be conducted before the intervention. For the actual study, a total of four intact science classrooms will be chosen from two public secondary schools located in Selangor state. Each class consists of at least 30 students. For each school, there will be two groups of students which undergo the same intervention—one group who takes CS as a subject while the other group does not. During analysis, each group will be further divided into two levels (high and low academic) to compare the effects of intervention. The study will be conducted for six weeks, including the administration of pre-test, posttest, delayed posttest, and treatments. The CT-integrated lesson plans which developed for the intervention will be validated by a panel of science experts. In data analysis, the statistical test of two-way split plot analysis of variance (SPANOVA) will be used to answer the first and second research questions. Subsequently, two-way ANOVA will be used to address research questions three and four to determine the possible combined effects of the CT dimensions.
5. Proposed Contribution

This study serves the purpose to inform science teachers that it is possible to develop students’ HOTS through argumentation. Meanwhile, it is crucial to make students aware of their CT competencies are closely related to their scientific problem-solving abilities. This study also serves to inform policymakers to focus on the development of students’ CT competencies as this can have an impact on the effectiveness of their learning. Further, this study can contribute to the existing body of the research on the integration of CT in STEM education, particularly to propose the design principles of CT-integrated instruction in science education.

References


Developing Personalized Nudges to Improve Quality of Comments in Active Video Watching

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Abstract: AVW-Space is an online video-based learning platform which aims to improve engagement by providing a note-taking environment and personalized support. This paper presents a PhD project focusing on the nudges about the quality of comments learners make on the videos in AVW-Space. We first automated the quality assessment of comments using machine learning approaches. Based on the predicted quality of the comments and the learners’ profiles, we developed nudges which encourage students to write better comments. Finally, we conducted a study in a first-year engineering course to analyze the learning effects of these nudges. This PhD research contributes to the development of personalized educational support for engagement in video-based learning via fostering better comment writing behavior.

Keywords: Video-based learning, learning analytics, intelligent support, personalized support, soft skills learning

1. Introduction

Video-based learning (VBL) has been a popular method in e-learning. Videos combine text, visual aids and sound to simplify complicated concepts for learners. Educational videos allow students to learn at their own pace and anywhere (Gilboy, et al., 2015). VBL is used in formal education, such as flipped classrooms, blended learning and Massive Open Online Courses (MOOCs), or for informal learning such as YouTube. However, VBL can be a passive form of learning since it lacks direct interaction between students and teachers (Yousef et al., 2014). Another challenge for VBL is supporting different types of learners (Chatti et al., 2016). There have been several approaches to providing personalized support for engagement in VBL, such as embedding annotation tools, forums and visual learning analytics (Chatti et al., 2016; Giannakos et al., 2016).

AVW-Space (Mitrovic et al., 2016; 2017) is an online VBL platform developed at the University of Canterbury. This platform aims at increasing engagement in VBL by a variety of approaches such as providing a note-taking environment, micro-scaffolds (aspects), reviewing notes and intelligent and personalized prompts (Dimitrova et al., 2017; Mitrovic et al., 2019). In AVW-Space, the teacher firstly selects instructional videos from YouTube. Then, the teacher should define some aspects as mini-scaffolds to direct the attention of students to the key concepts or to encourage students to reflect on their relevant experience or knowledge. Learning happens in two main phases in AVW-Space: Personal Space and Social Space.

In Personal Space, the learner can watch a video and pause it to write a comment. The learner must use one of the aspects defined by the teacher as a tag for the comment. Integrating a video annotation tool with VBL systems is a method to increase students’ engagement (Aubert et al., 2014). Previous studies on AVW-Space show that commenting causes deeper thinking and reflection (Mitrovic et al., 2017; 2019). The analysis of learners’ reflections has been an area of research which aims at gaining insights on learners’ engagement and their educational characteristics (Hoppe et al., 2016; Joksimović et al., 2018; Taskin et al., 2019). The knowledge extracted from the analysis of comments can help in developing pedagogical support for fostering engagement in different types of learners.

AVW-Space has some simple nudges as personalized interventions in Personal Space to develop active learning behaviors. However, these nudges are only for writing a comment on videos and using various aspects (Mitrovic et al., 2019).

In the second phase, the teacher chooses the comments to be shown in Social Space anonymously. Students read and rate the comments made by their classmates using the rating options.
defined by the teacher. The rating activity improves learning by sharing learners’ understanding. However, rating comments could be a frustrating task since the list of comments to rate includes many poor-quality comments. Thus, encouraging the students to write high-quality comments could make reviewing task more useful for the students (Mitrovic et al., 2017).

The goal of AVW-Space is to foster the essential metacognitive skills for effective learning such as self-explanation, self-reflection and self-regulation (Bannert et al., 2008). One of the early studies with AVW-Space showed that aspects scaffold engagement and reflection (Mitrovic et al., 2016). The rating options provided in Social Space also trigger reflective thinking (Mitrovic et al., 2017). Therefore, it is beneficial to provide more adaptive and direct support for self-reflection via nudges. There have been several computer-based learning environments which provide prompts to support meta-cognitive skills (Bannert et al., 2013; Daumiller et al., 2018). However, AVW-Space has no explicit nudges for fostering meta-cognitive skills in comment writing.

The main objective of this research is to develop a pedagogical intervention in AVW-Space to increase learning and engagement by improving the quality of comments. The initial nudges for commenting and using various aspects have previously been used successfully in AVW-Space to foster commenting behavior (Mitrovic et al., 2019). Thus, this research focuses on designing nudges which provoke deeper thinking and reflection in students while commenting. The following research questions should be addressed to achieve this goal:

1. How reliably can a quality scheme be used for assessing the quality of comments by human coders or machine learning models?
2. How can we design and develop personalized nudges to improve the quality of comments?
3. Do the nudges for improving comments quality increase learning effectiveness?
4. Can these nudges and quality assessment approach be applied to other types of skills in AVW-Space?

2. Methodology

In this project, we use data collected from the previous studies with AVW-Space (Mitrovic et al., 2016; 2017; 2019) where the students used AVW-Space as an online resource for training on giving oral presentations. All previous studies used the same videos: four tutorials on giving presentations, and four examples of real presentations. The data collected from the studies include comments made by students, their ratings and the profiles of the students who used AVW-Space. The learner profiles were gathered via surveys questions on demographics, background experience in giving presentations, and the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich et al., 1990). After using AVW-Space, students were asked to answer a post-study survey that included questions about giving presentations again to investigate whether students have learnt the new skill. The students were also given two other surveys: 1) NASA-TLX (Hart, 2006) to analyze the cognitive load and 2) Technology Acceptance Model (TAM) (Davis, 1989) to assess usefulness perception after using the platform.

To design nudges for improving the quality of comments, we first developed a quality assessment model. As a basis for this model, we proposed one quality scheme for comments on tutorial videos and another one for example videos. The scheme for tutorial videos classifies comments into five categories: 1) affirmative, negative or off-topic, 2) repeating, 3) critical and analytical, 4) self-reflective and 5) self-regulating comments. However, the scheme for comments on example videos only includes three categories: 1) affirmative, negative or off-topic, 2) repeating and 3) critical and analytical. After evaluating these schemes, statistical analysis and machine learning approaches were applied to drive insights from comments in different categories and automate the quality assessment of comments using a cost-sensitive random forest model (Mohammadhassan et al., 2020).

After analyzing the correlations between the student profiles and the quality of their comments, we designed a set of nudges to encourage students to improve the quality of comments. The design of the nudges follows the choice architecture-driven framework, where the nudges are in the form of a game dialogue: N=<G, P, T, O> (Dimitrova et al., 2017). In this game dialogue, G defines the pedagogical goal of the nudge, P represents the conditions where the nudge should be given to the
student, T is the text template of the nudge, and O is the expected behavior change after receiving the nudge. The P element evaluates the student profile, a history of nudges given to the student for the current video, the quality of comments made by the student on the current video and the video status. We designed seven new nudges for tutorial videos, and three new nudges for example videos. These nudges guide students towards critical-thinking and self-reflection. For example, if a student writes a short affirmative comment like “This is helpful”, the student will receive an immediate nudge for elaborating more on the video content. If a student often writes comments which merely repeat the video content, a nudge will be given to ask the student to think about the advantages, disadvantages, causes and effects. At the end of the videos, a nudge will be given to students who have not made any self-reflective comment on the video, asking students to relate their previous experience to what they have learnt from the video and plan how they can improve their skills in future.

To assess the effects of the new nudges on learning and engagement, we conducted a study with students enrolled in a first-year engineering course at the University of Canterbury, similar to the previous studies. All of the students used the same version of AVW-Space, which included the new nudges. We followed the ICAP framework (Chi et al., 2014) for characterizing students’ engagement. ICAP framework classifies learners’ overt behavior into four types: Interactive, Constructive, Active and Passive. Passive learners only receive information by watching videos. Active students perform additional actions like commenting, but their comments usually repeat the received information. Constructive learners add new information that was not explicitly taught, such as writing about their reflection on the video or their previous experience as well as their future plans for improvements.

We found that the students who made high-quality comments improved their conceptual knowledge significantly between pre- and post-test. A causal analysis indicates that only high-level comments contribute to the increase in knowledge. The comparison of the data from this study with previous studies showed that the new nudges increased the number of constructive students. Also, students made more comments in this study than in the previous studies. To investigate the differences in student characteristics and behaviors, we analyzed the students’ profiles for the different categories of students (their MLSQ scores, the number of videos they watched, the time spent in the system and the average interval between comments they made). This analysis showed that the constructive and active students spent more time watching videos and made comments in shorter intervals. However, there was no significant difference in the MSLQ scores. We also reviewed the feedback from students on the system to extract opportunities for improving the nudges and the system in future. The students found the nudges helpful in guiding their thoughts and reflections more than in previous studies. However, some students wanted to customize the frequency of nudges. Other students would like to see their progress in AVW-Space and review the nudges they received later. We analyzed the activities that students had in the whole study to mine constructive behaviors. We found constructive students pause and play the videos more often than other students. Also, most students write comments only when they receive a nudge, whereas constructive students show more initiative and write comments without waiting for a nudge.

3. Future Research

We plan to enhance AVW-Space in accordance to the student feedback from the study we conducted. We will then re-evaluate it in the second study with the same experimental design. These improvements could include adding an open learner model to the system and improving the nudges to make them easier to understand. Finally, we will investigate the generalizability of our approach by implementing it in different types of courses using AVW-Space. We have identified three main challenges of generalizing nudges to other domains so far. Firstly, we need an approach that could extract the domain vocabulary of the course. Secondly, the quality prediction model might need to be improved to capture different domains. Thirdly, we need to investigate whether the current nudges are applicable and useful for other topics. We will try to address these main challenges in the further work of this project.
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References


Investigating the effectiveness of composite making instructions on secondary school integrated STEM education

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Abstract: Researchers are exploring efficient approaches to promote integrated STEM education. Though some studies have adopted making as an instructional design to develop K-12 students, few of them have purposely explored the effectiveness of different composite making instructions in cultivating learners’ multiples capabilities. To fill the gap, this empirical study proposes to evaluate the effectiveness of using making only, with mentoring, and with authentic problem instructional strategies on secondary school integrated STEM education. It aims to exam the changes of students’ creativity, critical thinking, STEM identity, and STEM interest development after participating in the pre-designed STEM making interventions. In this proposal, we will illustrate our research motivations, research questions, methodology, and the expected implications of the study, hoping to gain some constructive suggestions to improve this dissertation work-in-progress.

Keywords: Integrated STEM education, making, mentoring, authentic problem

1. Introduction

As maker movement becomes a cultural trend in the education field, people started to regard making as an instructional strategy to foster students’ 21st century skills and psychological perceptions towards STEM education (Godhe et al., 2019; Honey, et al., 2014). Although some scholars have assessed the performance of making approach in promoting K-12 student development, few attentions have been paid to search about the mechanisms of different composite making instructions, of which the elements of mentoring and authentic problem-solving could be involved, in integrated STEM (Vongkulluksn et al., 2018). Particularly, it is desirable for educators to acquire more experience of applying various composite making instructions in the context K-12 integrated STEM education. To meet the research need, we plan to implement an empirical study to investigate the effectiveness of diverse making instructional strategies in developing secondary school students’ cognitive skills (e.g., creativity and critical thinking) and non-cognitive skills (e.g., STEM identity and STEM interest). Three experimental conditions, of which the instructional strategies of making only, with mentoring, and with authentic problem, will be manipulated. Accordingly, there are a series of guiding questions for the current study:

- Does a making with mentoring instructional design improve students’ creativity, critical thinking, STEM identity, and STEM interest compared to a making instructional design?
- Does a making with mentoring instructional design improve students’ creativity, critical thinking, STEM identity, and STEM interest compared to a making with authentic problem instructional design?
- Does a making with authentic problem instructional design improve students’ creativity, critical thinking, STEM identity, and STEM interest compared to a control condition?
2. Literature review

The popularity of integrated STEM education activities in K-12 schools is attracting people’s attention (Honey, et al., 2014). This phenomenon mainly due to the potentials of using STEM education to prepare youth to face the uncertainties that we have never encountered before in the future world. For example, problems of public health, education equity, and environmental protection in the modern industrial society (Chiu & Lim, 2020; Jong, 2020). While, developing students’ skills through STEM education reform is a challenging task (Chai et al., 2020; Geng et al., 2019). In the practice, one of the strategies adopted by educators to realize this cross-disciplinary innovation is to introduce making instruction to students. The hands-on experience of making activities can bring students opportunities to cultivate their interest in learning STEM (Vongkulluksn et al., 2018), practice their creativity and critical thinking skills (Jeng et al., 2020), and build their identities of being a member in the STEM related areas (Schlegel et al., 2019). Besides the promising outcomes of using making approach, this method is compatible with other instructional elements to facilitate integrated STEM education. It is noticeable that some studies have involved mentors and authentic problem strategies while implementing the making activity designs (Sheffield et al., 2017).

Though some scholars have investigated the feasibilities of adopting making activities, mentorships, and authentic problems to enhance integrated STEM education (Yin et al., 2019), it is rare for the existing research to compare the effectiveness of making instruction, making with mentoring instructional method, and making with authentic problem design in promoting secondary students’ multiple capabilities (Jeng et al., 2020; Schlegel et al., 2019). However, from the perspective of educational practice, it is crucial to investigate different instructional designs and identify their effectiveness to maximize the learning outcomes for K-12 students. Thus, a careful mix of different instructional elements to facilitate integrated STEM education is highly recommendable in the area. The proposed study will implement three diverse making programmes in secondary schools. Students’ creativity, critical thinking, STEM identity, and STEM interest changes affected by the research interventions will be detected. Educators can identify the efficiency of different making instructional designs from this investigation and pinpoint the most effective strategy to implement making activities to cultivate students’ competences in integrated STEM.

3. Methodology

3.1 Research samples

A convenient sample method will be adopted to approach the research sites. Researchers will try to get access from the secondary school teachers to conduct the making programmes. Three classes of secondary students will be invited to participate in the study. They will be asked to accomplish the STEM making projects, named Smart Traffic Light Design, by using Arduino kits.

3.2 Experimental interventions

The researchers propose to use Design-Based Implementation Research (DBIR) method (Fishman et al., 2013; Jong et al., 2017) as the investigation approach. One control group and two experimental groups will conduct the research interventions respectively. The teacher in the control group will adopt making instruction to implement the making programme. Teachers of the two experimental groups will introduce other elements, including mentorships and authentic problems, to their integrated STEM making activities. For instance, students in experimental group one will receive help from the mentors while designing and making their artifacts, students in experimental group two will be assigned authentic problems to solve. This study will last for seven weeks in the participating schools, of which students will have the integrated STEM class every week. There will be four phases of the intervention, including pre-test, programme implementation, post-test, and semi-structured interviews.
3.3 Research scales

A 5-point Likert-type questionnaire, of which the scales solicited ordinal responses from 1 = strongly disagree to 5 = strongly agree, will be distributed to all the student participants. The questionnaire is designed to measure students’ creativity, critical thinking, STEM identity, and STEM interest. All the items of the questionnaire should be adapted from the previously published academic works, and the Cronbach Alpha value of each subscale will be checked.

3.4 Semi-structured interviews

Semi-structured group interviews will be conducted to probe into the effectiveness of adopting making only, with mentoring, and with authentic problem approaches on students’ creativity, critical thinking, STEM identity, and STEM interest development. Additionally, participants’ perceptions of using different making instructional strategies to promote integrated STEM education will be explored by semi-structured interviews.

3.5 Data analysis

This study will use mixed research method. ANCOVAs will be operated to analyze the differences between the pre-test and post-test of the three groups, grounded theory (Taber, 2000) will be adopted to process the interview data.

4. Expected implications

This research will contribute to the development of integrated STEM education both from the academic and practical perspectives. It provides empirical evidence for the effectiveness of three instructional strategies (including making only, with mentoring, and with authentic problem) in promoting secondary school students’ multiple capabilities (Schlegel et al., 2019; Vongkulkuksn et al., 2018). As the corresponding effects of the three instructions will be identified, educators can learn from this experience and design the most effective approach accordingly (Chiu & Churchill, 2016) to cultivate students’ creativity, critical thinking, STEM identity, or STEM interest.

References


Discovering the Relationships Between Uncertainty Utterances and Knowledge Building in Cross-culture Online Collaborative Learning

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Abstract: Previous studies focus on uncertainty expressions and how it is managed among basic and secondary education level students in a collaborative learning context. Although it has been reported that uncertainty serves as a motivation for learning, little is known about how it relates to knowledge building. In this paper is presented an essential aspect of the research area which focuses on uncertainty utterances and how they relate to knowledge building. This study seeks to examine how graduate students communicate, negotiate their uncertainties during online collaborative discussion writing to build on their knowledge and determine the relationship between uncertainty utterance and knowledge building. Insights into the data collection and proposed method of analysis are discussed, and explanation from peers. The findings of this study will pave the way for future studies to investigate uncertainty in different geographical contexts and subjects or courses.

Keywords: Uncertainty utterance, Knowledge-building, Cross-cultural collaborative learning

1. Introduction

The internationalization of higher institutions in China, most universities have enrolled international students from different cultures, which makes the universities a multicultural environment. In China, some universities offer the English-taught programs which sometimes attract Chinese students. Some students come from countries where the English Language is not the native nor official language but have good English language proficiency. This increasing nature of multicultural environment requires critical attention by instructors (Parris & Linder-VanBerschot, 2010). Students at the higher education level need to be trained for cross-cultural relations and communication skills. Collaborative learning (CL) promotes social interaction, learning and generating ideas among collaborators. Furthermore, through social interaction, individuals express uncertainty (Smithson1989). By interacting with each other in a collaborative dialogue, students negotiate to tackle uncertainty (Lund, et al., 2019). However, there is no study of how uncertainty correlates with knowledge building, especially with culturally heterogeneous groups. Furthermore, existing cross-culture studies focus on promoting cross-culture knowledge and understanding, and students’ perceptions. Concerning China, most cross-cultural collaborative studies focus on 2 country cultures such as China and Canada (Shi et al., 2013) or China and the US (Angelova & Zhao, 2014). Hence, significant to explore uncertainty in cross-culture collaborative learning and the significance of uncertainty expressions concerning knowledge building. To fill this research gap, this study aim to: 1) Identify how culturally diverse groups build on their knowledge amid uncertainty in an online learning environment, and 2) determine how uncertainty utterance relates to knowledge building among culturally heterogeneous groups.

2. Literature Review

2.1 Cultural Context and Uncertainty in Collaborative Learning
In this study, culture is defined by national culture, which is an individual’s country culture, which according to Hofstede (1990), is the collective encoding of the mind, that can be used to distinguish people from different countries. Culture is densely related to language use and communication (Alvesson, 2004). Studies on cross-cultural collaborative learning reveal the benefits such as cross-cultural understanding and knowledge (Kersten & O’Brien, 2011), and challenges such as students preferring to collaborate with individuals from their country (Moore & Hampton, 2015; Kumi-Yeboah, 2018). Studies such as Baker et al. (2005) show that some students prefer same culture groups whereas others are positive towards studying with individuals from other countries. This is as a result of group members that are active and make collaborative discussions challenging (Fozier & Valet, 2012) and stimulate uncertainty. In diverse group discussions, there is uncertainty about social interaction, known as relational uncertainty and uncertainty about the content or topic of discussion known as epistemological uncertainty (Hartner-Tiefenthaler, Roetzer, Bottaro, & Peschl, 2018). Collaboration becomes challenging when there is uncertainty due to cultural differences. posit that the feelings of uncertainty play an imperative role in learning during collaborative learning (Jordan et al., 2012). Uncertainty when expressed in a collaborative activity, presents prospects for social interaction that is geared towards learning, through questioning, researching, inquiring, explaining, and generating solutions (Costache et al. (2019); Kapur & Bielaczyc, 2012). Social interaction is influenced by culture as individuals within themselves have different ways of thinking, behaving, and feelings (Vatrapu & Suthers, 2007), concerning learning (Setlock et al., 2004). Also, individuals from different cultural orientations have been found to either have a “high or low uncertainty avoidance”, where the unknown becomes a threat to culture (Hofstede et al., 2010). In this study, we define uncertainty as to the experience, thought, or feeling of the unknown that results in a deviation from target goals.

2.2 Uncertainty and Knowledge Building in Cross-cultural Collaborative Learning

Uncertainty is important for knowledge-building communities because, they embody and create knowledge, with causes and effects, and approaches to “epistemological indeterminacy” are solved directly (Murray, 2006). Pesaresi and Zhang (2019), define uncertainty as a strategy for idea generation and enhancement in knowledge-building discourse. According to Afifi and Afifi (2009), the experience of uncertainty is represented as a signal of ones understanding about something which affects input and decisions. Cross-culture online collaborative learning should promote idea generation, idea organization, and intellectual convergence to construct knowledge. Yet, when individuals face situations of unknown outcomes such as reactions to comments and ideas, uncertainty arises (Babrow, 2001), which can hinder knowledge building if not managed positively. However, as students interact more on the content, they explain to each other thereby processing more information (Zheng et al., 2015). Students may discuss or question deviating contributions which will help them negotiate to arrive at the right answer (Weinberger et al., 2005). According to Hartner-Tiefenthaler et al. (2018), uncertainty at the beginning of collaborative discussion is relational uncertainty, which when overcome by students incite engagement and epistemological uncertainty sets the pace for knowledge building. However, students need to express their uncertainties, which serve as a motivation for knowledge building (van Heigst et al., 2019). Also, there or instances that some students contribute less or tasks are ignored (Näykki et al., 2017), when they are uncertain about the content. Therefore, it is important to guide students and support them to view uncertainty as an opportunity to learn. Yet, there is a lack of studies on how uncertainty and knowledge building correlate. Therefore, this study will examine if there is a relationship between uncertainty utterances and knowledge building.

2.3 Research questions

To explore uncertainty and knowledge building among diverse cultural groups, it is important to first determine how students communicate their uncertainty and the choice of words in the English language. Furthermore, the proposed study will examine how students from different cultural backgrounds students utilize uncertainty to build on their prior knowledge and determine whether there is a relationship between uncertainty expressions and knowledge-building during cross-culture collaborative learning. Therefore, the study seeks to answer the following research questions:
RQ1: a) How to identify uncertainty utterances in cross-culture collaborative knowledge building discussions? b) What is the students’ choice of words for expressing their uncertainties in cross-culture collaborative learning?
RQ2: How do cross-cultural groups negotiate uncertainty to increase knowledge building?
RQ3: Is there a relationship between uncertainty utterances and knowledge building in cross-culture collaborative learning?

3. Proposed Methodology

3.1 Participants

Participants in this study will comprise graduate students from different countries including China in Beijing Normal University. The proposed sample size is 120 students from both collectivist and individualistic cultural orientations. Prospective participants will be graduate students in groups of 4 who can read and write in English language for discussion and have prior knowledge in Introduction to Information Communication Technology (ICT) from their undergraduate studies will be eligible.

3.2 Proposed research procedure

For this study, a carefully designed collaborative script to support cultural differences and expected reactions will be employed to minimize the effects of different cultural backgrounds on students’ engagement during collaborative learning. The collaborative learning task design will be based on a textbook on Introduction to ICT on the topic Data Storage and Protection. The task will be a problem case for students to discuss and solve. All the discussions will be online and students will be required to discuss by text. All groups will be given the same collaborative task. The final group product will require students to generate a solution for a problem scenario. Hofstede’s (1997) individualism index for cultural orientation will be used to guide the group formation process. Each group will comprise 2 students from individualist cultural orientation and 2 students from collectivist cultural orientation. The entire study will take 4 hours and 30 minutes, spread in 2 days. For day 1, an orientation will be conducted for participants and group members will be asked to introduce and get familiar with each other in 30 minutes. Day 2 will be for the main collaborative activity, which will last for 4 hours. Finally, this study will exempt face-to-face discussion and hence, all discussions will be in an online learning environment.

3.4 Data collection and analysis

The main data to be collected will be the English language text from students’ online discussion. Students' discussion will be downloaded and stored for analysis. To answer the first research question, the quantitative content analysis method will be employed (Hara, Bonk, & Angeli, 2000). The words sample will be coded and counted for each group under each category of expression. Two experts will be invited to assist with the coding for inter-rater reliability. The strategies cross-cultural groups adopt to overcome their uncertainties will be identified. To determine whether uncertainty expressions can be related to knowledge building, first, the IIS-Map-Based analysis tool by Zheng et al. (2012) will be applied to first draw a target knowledge map, then input knowledge sentences in the tool to automatically calculate knowledge activation quantity for each group. With the IIS-Map-Based method of analysis, each sentence will be segmented in this order: Time, Information processing learner (IPL), Cognition level, Information type, Representation format, and Knowledge sub-map. After, correlation analysis will be performed on the sum of uncertainty utterances and knowledge activation quantity for each group with the IBM SPSS 26.0 version. Thus, to determine if there is a relationship between the number of uncertainty utterances and knowledge building process.
4. Proposed contribution

The proposed study has its significance and contributions to the research area as it aims to draw out significant aspects of uncertainty and students’ cultural orientation in collaborative learning among culturally heterogeneous groups. The study will contribute to the research area as it will throw light on how practitioners can identify how students communicate when they are uncertain about subject, topic, or contribution, just to mention a few. The findings from this study will serve as an eye-opener for researchers to further explore the role uncertainty is likely to play from a cross-cultural collaborative learning perspective and serve as knowledge for future studies to examine different interventions. Most importantly, the study will contribute a novel method of analysis for identifying the relationship between uncertainty utterances and knowledge building.

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References


Teachers’ Conceptions and Uses of Interactive Spherical Video-based Virtual Reality in Teaching Chinese Writing

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Abstract: This study integrates interactive spherical video-based virtual reality (ISV-VR) into Chinese descriptive composition education. This paper reports teachers’ conceptions of teaching with regards to the use of interactive spherical video-based virtual reality (ISV-VR) in Chinese descriptive composition writing. The findings may provide researchers and practitioners with novel insight into the teaching of composition writing in the contexts of first language acquisition supported by virtual reality technology.

Keywords: Virtual Reality; writing education; teacher conception; phenomenographic method

1. Introduction

1.1 Research background

Innovative technologies are changing not only the way of living and working but also the way of teaching and learning (Jong, Shang, F. L. Lee, & J. H. M. Lee, 2008, 2010). Technology-enhanced learning (TEL) considers “the use of information communication and technology (ICT) in its widest sense to support and improve the learning experience” (Gordon, 2014). Spherical videos can offer users an all-round view of places at the same time (Chang, Hsu, & Jong, 2020). Interactive spherical video-based virtual reality (ISV-VR) is regarded as one of the new useful tools for supporting learning and teaching activities in which “students’ observation” is an important pedagogic component (Chien, Hwang, & Jong, 2020; Geng, Chai, Jong & Luk, 2019).

Writing education is one possible area that may benefit from ISV-VR technology. According to the recent reports of the Hong Kong Diploma of Secondary Education Examination (e.g., Hong Kong Examination and Assessment Authority, 2018), the major problems with students’ Chinese composition writing include the lack of detailed description, the monotonous expression, and the affectionless writing. The report conjectured that this problem could be due to students’ lack of observations about daily-life and their lack of in-depth understanding of the communities. The report alluded that students may lack observation in daily life and they may lack understanding of people, communities, and society. Therefore, improvements in Chinese writing education by facilitating students’ observation and understanding of people, communities, and society is needed.

ISV-VR is not constrained by time and space (Jong, Tsai, Xie, & Wong, 2020). It provides students with alternative opportunities and perspectives for observing places and the people therein (Chang, Hsu, Kuo, & Jong, 2020). By adjusting their viewing angles, students can explore and observe elements in the scene more closely, which can better stimulate their thoughts (Lin, Yu, Sun, & Jong, 2019). Moreover, students can observe their communities more comprehensively with ISV-VR, which can foster them to better understand the context of communities and make reflections on their life.

Accordingly, this study leverages on the ISV-VR technology to transform the writing pedagogy for descriptive writing. As teachers are the key agents in all education reform, this study examines the teachers’ conceptions and uses of ISV-VR in the context of teaching Chinese descriptive composition.

1.2 Preliminary research questions
Research question: How do secondary school teachers conceptualize VR and its uses in teaching Chinese descriptive composition?
Sub research questions:
   a) What are the variations in teachers’ conceptions of VRDW?
   b) How are the conceptions of each teacher distributed?
   c) What are the typical cases in the teacher's conception of VR and its uses?
   d) How to interpret teachers’ conceptions of VRDW from the lens of TPACK?

2. Literature review

VR enables students to immerse themselves in a virtual environment comparable to the authentic world (Lin & Lan, 2015; Mantziou, Papachristos, & Mikropoulos, 2018). It provides a safe and self-directed environment that enables students to observe places at length, with or without their teachers’ guidance in the classroom.

Literature from immersive language learning approaches highlights the need for a rich and authentic environment to provide the socio-cultural context for learners to develop nuanced understandings of language in use (Cummins, 2000; Marsh, Hau, & Kong 2000; Swain & Lapkin, 2005). Research in embodied cognitive science also attests that situated immersive learning can stimulate students’ learning motivation, enhance the learning experience, and encourage knowledge transfer (Marsh et al., 2000; Swain & Lapkin, 2005; Wilson, 2002). The technical skills of producing ISV-VR content is easy to master, therefore, most school teachers can develop courseware according to their own teaching needs (Chen et al., 2019; Chien et al., 2020). However, little attention was given to the teachers’ conceptions of adopting VR technology for first language learning according to the literature review.

ISV-VR is a new educational tool that supports learning and teaching activities in which “students’ observation” is an important pedagogical component (e.g., Chang et al., 2020; Chen et al., 2019; Chien et al., 2020; Geng et al., 2019; Jong et al., 2020; Lin et al., 2019). Given the affordances of ISV-VR that may address the pedagogical challenge of fostering descriptive writing, an ISV-VR supported Chinese writing learning program is designed; and this study looks into the teachers’ conceptions of using ISV-VR to teach descriptive writing.

3. Proposed methods

The purpose of this study is to explore teachers’ conceptions and uses of ISV-VR supported Chinese writing learning and to find variations in their experience. To this end, the phenomenographic approach (Marton, 2005) was employed. The data collection for this study has been completed. The data were collected from teacher interviews, class observation, and other supplementary materials (student interviews, teachers’ reflection notes, and document data). Twenty-one grade 7-9 secondary Chinese teachers from a school in Hong Kong participated in the current study. In the design VR curriculum, there were five stages in each teaching cycle: 1) basic Chinese knowledge learning, 2) reading passages learning, 3) observing the landscape with ISV-VR, 4) writing descriptive compositions on related topics, and 5) evaluation and feedback. The interviews were conducted after each teaching cycle.

Data were collected through semi-structured interviews. In other words, a list of predetermined open questions that focused on the teachers’ ideas and experiences about ISV-VR supported Chinese writing learning was used to prompt teachers’ reflection on Chinese writing instruction. Additionally, follow-up questions such as “Could you give me an example?” and “What do you mean by that?” were used to invite teachers to elaborate on their ideas. Teachers were interviewed in Mandarin Chinese or Cantonese by a trained researcher. The interview time ranged from approximately 40 to 60 minutes. All the interviews were audio-recorded and transcribed word for word.

Regarding the designed VR curriculum, the teaching plan of each unit was worked by some core teachers through joint lesson preparation. When implementing the teaching plan, each teacher designed different teaching activities and procedures according to the academic level and prior
knowledge of students. Therefore, in order to have a more accurate, comprehensive, and detailed understanding of teachers' VR teaching experience, before the interview, the researcher also observed each teacher's reading classes and VR writing classes. The researcher used record sheets to record the activities of teachers and students, as well as the interactions between teachers and students. After class observation, the researcher communicated with the teacher about the pedagogical design or the teaching objectives of the teaching activities. Through classroom observation, the researcher had an initial understanding of the different pedagogical designs of each teacher, which provided a basis for follow-up interview questions.

The transcripts will be analyzed iteratively. The data analysis process will start with reading through the transcripts as a whole for several times to gain familiarity with the students’ ideas. Next, the key meanings expressed in the transcripts will be highlighted and marked with some keywords that best describe the teachers’ views regarding Chinese writing and using the ISV-VR to teach Chinese writing. The key meanings will be then compared and contrasted to identify similarities and differences between them. Then, structural relationships that related or distinguished the key meanings will be examined.

4. Implications of expected results

This study will contribute to the current literature by describing a range of conceptions of teaching that may empower or limit teachers’ use of VR technology for the teaching of composition writing. Teachers’ conceptions of VR will influence their use of this technology (Lin, 2016; Kong, 2018; Wang & Matsumura, 2019). Knowledge of teachers’ conceptions may also provide workable insight for teacher trainers and policymakers to enhance educational practices (Kelly & Beth, 2017).

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Improving Skills for Peer Feedback on Spoken Content Using an Asynchronous Learning Analytics App

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Abstract: Peer feedback can have a powerful effect on language learning outcomes. However, training students to successfully provide peer feedback and the subsequent evaluation of that feedback can be challenging. The first author’s Ph.D. dissertation research will investigate how to improve that training process within the context of English as a foreign language education. First, this paper will describe the preliminary research questions and the motivations underlying these questions. Then, it will describe the design and development of the alpha version of a web app that supports training students to provide peer feedback on spoken content. This app will also be able to act as a platform which supports learning analytics (LA) research. Finally, this paper will lay out the proposed research methodology for moving forward.

Keywords: Peer Feedback, Learning Analytics, Technology Enhanced Language Learning

1. Introduction of Preliminary Research Questions and Research Contribution

Peer Feedback can have a powerful effect on language learning outcomes. However, training students to successfully provide peer feedback and the subsequent evaluation of that feedback can be challenging. In light of this, the authors propose the following preliminary research questions:

Question 1: How and to what extent can an asynchronous web app improve the skills of students for providing peer feedback on spoken content in the context of English as a foreign language (EFL) education?

Question 2: How and to what extent will the use of the asynchronous web app impact the performance of students on speaking tests?

Question 3: How and to what extent can the learning analytics data collected about students be used to modify the design and implementation of the asynchronous web app?

There are several contributions that this research can make. First, it can provide evidence of the efficacy of an asynchronous web app as a tool for improving peer feedback training. Second, it can demonstrate the efficacy of the app in improving student performance on speaking tests. Third, it can demonstrate how learning analytics data can be used to inform design and implementation decisions while developing and using the app through multiple iterations. Finally, this research can lay some groundwork for future research on peer feedback with learning analytics and technology enhanced language learning.

This paper will describe the design and development of the alpha version of an asynchronous web app that supports peer feedback on spoken content (as opposed to written content). First, this paper will briefly introduce the motivations for this research and the inspirations for the app. This will include some of the background literature which supports the inclusion of peer feedback in language learning and in learning in general. The following section will detail the design and development of the app. The last section will propose the research methodology.
2. Research Motivation and Research Methodology

2.1 Pebasco App Background

The initial idea for this web app was inspired by observations of the implementation of a synchronous pedagogical practice used in some EFL university courses in Japan called Timed Pair Practice (TPP). The authors thought that it could be improved by the integration of peer feedback. The concept was that students could do traditional synchronous TPP activities with their teacher in class and then they could use a web app to engage in supplemental asynchronous practice that is similar in approach to TPP and would involve giving and receiving peer feedback that is guided by teacher scaffolding.

The naming of “Pebasco” for this app comes from the underlined letters in the following phrase: “peer feedback on spoken content”. The next section will provide more detail on Timed Pair Practice. The section after that will introduce background literature related to peer feedback.

2.2 Timed Pair Practice

One of the authors has taught at two universities in Japan which have included Timed Pair Practice (TPP) in their EFL curriculum. The author was intrigued by its effectiveness and wondered how it might inform the development of technology enhanced language learning. Because of this, it became one of the inspirations for the development of the Pebasco web app.

“TPP is a Task-Based Learning approach that incorporates random impromptu interactions and Corrective Feedback to help students identify and repair their errors” (Elam, 2014, p. 17). In its most basic form, the creator of TPP (Moe, 2005) describes the process as simple: two students are randomly selected and allowed to converse until one of them makes an uncorrected mistake at which time their conversation is stopped. The duration of the conversation is timed from start to finish. After the uncorrected error has been pointed out, two more students are randomly selected and the procedure repeated. An average of all the times of a student’s conversations and the average number of attempts made to converse in a class are used as the basis for making an evaluation of the student’s performance. (pp. 197-198)

It is also worth noting that there are many different variations on the basic form of TPP. For instance, at the author’s institution, when a pair of students performs a TPP test, in addition to receiving credit for the standard metrics (i.e. length and number of conversations), the students can be awarded addition credit based on the quality of the content of their conversations (e.g. the use of follow-up questions; novel or creative phrasing; supporting- or counter-arguments; etc.).

Research has demonstrated that the TPP approach has improved both the length and quality of student conversation (Pipe, 2015). However, there are some suggestions that the approach can be further improved by incorporating technology (Moe, 2005) and more error recognition and correction by students (Elam, 2014). These calls for technology integration and the inclusion of peer feedback form the starting points for the design of the Pebasco app.

2.3 Peer Feedback

In Hattie’s (2009) work synthesizing hundreds of meta-analyses of learning success, feedback was identified as one of the top ten strongest influences on student achievement. Feedback was found to have an effect size of 0.75, nearly double that of the average effect size. Furthermore, feedback is not only unidirectional from teacher to student. Effective feedback can be given from student to teacher and also from peer to peer (Hattie & Clarke, 2019). It must also be noted that feedback can also have a detrimental effect on learning in some cases. Regardless of its positive or negative effect, the importance of peer feedback can sometimes be overlooked by teachers who are only focused on giving feedback from themselves to their students. Because of this, Hattie (2012) says “teachers who do not acknowledge the importance of peer feedback, and whether it is enhancing or not, can be most handicapped in their effects on students” (p. 273).

Unfortunately, feedback is not always easy to do correctly because there is considerable variability in its effectiveness (Kerr, 2020). In light of this variability, Hattie (2012) asserts that “more
research is needed on how to ensure feedback is given so that it is appropriately received, and there are few instruments that assess the frequency, types, and impact of feedback in classrooms” (p. 274). There is wide agreement that there needs to be more research conducted on feedback in order to improve effectiveness (AlFallay, 2004; Patri, 2002; Struyven et al., 2003). There has also been a call for the development of standardized tools to facilitate research in this area (Magin & Helmore, 2001). Hattie (2012) describes the future of feedback research as “exciting” and says that it “should set out to discover not only how to embed feedback in instruction but also to assist students to seek feedback, evaluate feedback (especially when provided by peers or the internet), and to use it in their learning” (p. 275).

To summarize, peer feedback is an important tool that teachers should implement in their teaching practice, but it can be challenging to do effectively. There is also a need for research into peer feedback and learning analytics tools to help inform that research. Furthermore, the previous section noted that TPP practitioners (Elam, 2014; Moe, 2005) have called for an expansion of TPP that includes technology enhanced language learning and peer feedback. These factors were considered when developing the alpha version of the Pblasco app, a tool that can help teachers to model feedback and students to give and receive feedback. It is the first step in developing a system that can fill the role of a standardized tool with built-in learning analytics functionality which can further advance research on peer feedback.

2.4 Design and Development of the Alpha Version of the Pblasco App

When students are watching their classmates do TPP testing in class, they repeatedly have the opportunity to observe the instructor identify mistakes. The basic concept underlying Pblasco is to allow students to assume the same role as the instructor. In an asynchronous setting, they can identify a particular point (i.e. timestamp) in a classmate’s recording of spoken content and then they label it with a comment identifying the mistake at that point. This allows the students to practice giving peer feedback in a context that is related to the TPP testing that they do in their classrooms. Unlike TPP testing, students using Pblasco can give multiple comments on one recording. After that, the teacher gives feedback on the Pblasco recordings in the same manner as the students (linking specific comments to timestamps). Finally, the system gives the ability to compare the comments on recordings; namely how closely a student’s peer feedback aligns with the teacher’s feedback on the same recording.

The authors decided to borrow the idea of a minimum viable product (MVP) from the world of entrepreneurial start-ups. This approach involves the creation of a low-cost prototype which has the minimal amount of functionality to be useful for the target end-user. It is intended to be more of a proof-of-concept than a full-fledged product. The authors set about finding the least expensive and fastest way to build an alpha version of the Pblasco app using existing discrete technologies.

The author who uses TPP in their EFL classes evaluated the educational technology that was currently being used to see if any of their affordances could be leveraged in the design of the alpha version of the Pblasco app. Three tools stood out as being particularly promising. The first is Flipgrid, a free online web app which is owned by Microsoft. It allows teachers to assign prompts to their students and the students reply by uploading brief video clips. Teachers can respond to the posted comments in many ways, including video replies, text comments, and rubric scoring, while students can respond by adding “likes” or replying with a video upload. While Flipgrid is popular with students and it offers opportunity for student interaction centered on spoken content, it lacks clear functionality for allowing teachers to scaffold and improve peer feedback. Furthermore, it allows teachers to give feedback on the overall video, but it does not allow them to target the feedback to a specific timestamp in the video, a feature that would be invaluable for EFL teachers who regularly need to draw students attention to specific areas (e.g. such as in TPP).

The second is the Microsoft Office 365 suite of apps. It includes Teams, a learning management system and video chat platform, and Forms, a platform for creating and distributing surveys and recording the responses. The third tool is Google Data Studio, which is a free platform for providing a data visualization dashboard for the students to compare their feedback to the teacher’s and their classmates’. This free technology stack (Flipgrid, Microsoft Office 365, and Google Data Studio) was accessible to the authors and served as the backbone of the alpha version of the app design.
2.5 Proposed Research Methodology

In October 2020, approximately 120 first year students enrolled in a compulsory basic EFL course at a Japanese university will be invited to take part in this study and sign a consent form. During the course, they will have five TPP speaking tests. As one element of preparation for these tests, they will be asked to use the alpha version of the Pebasco system. First, they will receive an assignment in the Microsoft Teams LMS for them to record a 30-60 second video in Flipgrid within a designated time. After that, the LMS will give them an assignment that includes a link to the collection of their classmates’ videos and a link to a Microsoft Form. In the Form, they indicate which classmate’s video they are providing feedback on and the timestamp of the first mistake that they have identified along with a description of that mistake (e.g. grammar mistake or pronunciation mistake). A student can identify up to three mistakes per video. Each student is required to provide feedback on five of their classmates’ videos, using a new Form for each video. When the teacher and students have all submitted their feedback, the students will be provided a data visualization dashboard via Google Data Studio so they can reflect on how their feedback compares to their teacher’s and their classmates’. Data collected from Microsoft 365 and Flipgrid will be used to evaluate (1) Pebasco’s effect on students’ ability to provide peer feedback, (2) Pebasco’s effect on students’ performance on the TPP tests, and (3) modifications to the design and implementation of Pebasco.

The evaluation of (1) Pebasco’s effect on students’ ability to provide peer feedback will be based on a comparison of how well a student is able to identify the same mistakes as the teacher in successive rounds of Pebasco use. The evaluation of (2) Pebasco’s effect on students’ performance on the TPP tests will be twofold. The first evaluation will be based on a comparison of how well a student performs on successive TPP tests which are administered after rounds of Pebasco use. The second evaluation will compare the TPP test performance of the experimental group of students in the autumn term (described in the preceding paragraph) to the TPP test performance of a similarly sized control group of students who took the same course, but did not use the Pebasco system. Finally, data from the (1) and (2) evaluations will be supplemented by student surveys and teacher observations to inform possible modifications to the design and implementation of Pebasco. New iterations of Pebasco will be tested from the start of the new school year in 2021. A comparison of the subsequent iterations of Pebasco will be used to evaluate the (3) modifications to the design and implementation of Pebasco.

References
Reflective Experiential Learning: Improving the Communication Skills of Software Engineers using Active Video Watching

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Abstract: Communication skills are an essential competence for software engineers. However, teaching communication skills in a customary educational setting is costly and time-consuming. This paper presents a PhD project, which focuses on adopting active video watching (AVW) for teaching Software Engineering students how to improve their communication in face-to-face meetings. The paper outlines the objectives and research methodology. An instrument to measure face-to-face meeting communication skills of Software Engineering students was developed and validated during the first phase of the study. In the second phase, we investigate the impact of an active video watching system on software engineering students’ face-to-face meeting communication skills. In the last phase, this project will enhance the AVW platform by identifying and designing a teaching approach that scaffold interactive learning behaviours amongst students during active video watching and examine the efficacy of the method on software engineering students’ face-to-face meeting communication skills.

Keywords: face-to-face meeting communication, active video watching, instrument validation.

1. Introduction

Communication skills are perceived as fundamental for Software Engineering (SE). Although communication proficiency is not the sole focus of the SE occupation, keeping in mind that the critical responsibility of software engineers includes interacting with different types of stakeholders, the significance of communication competence in the software development discipline is highly amplified (Werner et al., 2017). Hence, the ability to communicate effectively is crucial in the SE profession (Eggleston & Rabb, 2018). According to Almeida et al. (2019), face-to-face communication amongst software engineers happens quite often, and it is primarily related to team collaboration. In addition, the authors summarise that the oral communication abilities essential for the workplace are proficiency in face-to-face meeting interactions, dyadic interactions, interpersonal communication and negotiation.

Although the significance of face-to-face communication skills to SE activities are well evidenced in the literature, teaching these skills to university students is challenging as they demand extra efforts and resources (Anthony & Garner, 2016). Soft skills are usually taught in the context of a software development project course (Marques et al., 2018). Students need to learn how to rephrase under several situations, receive and reflect on feedback, to be able to retain and apply the skills in their future careers. Instructors struggle to provide this extra training effectively because of the already jam-packed and over-demanding curriculum (Harichandran et al., 2014).

Video-based education is particularly useful for teaching soft skills, where the process of learning requires contextual experience to retain knowledge (Cronin & Cronin, 1992; Mitrovic et al., 2017). While videos are very popular learning media, students tend to be passive while watching videos. In order to learn effectively from videos, students need to actively engage with the learning material (Chatti et al., 2016; Chi & Wylie, 2014). Numerous projects have coupled interactive features (such as quizzes and collaborative annotation) into video-based learning to improve student engagement (Chatti et al., 2016; Yousef et al., 2014). Even though these approaches increase student engagement, they demand extensive effort from educators during the production of video materials, and also require sophisticated learning platforms. Based on the findings and suggestions of previous studies, this
research project will expand the empirical discussion by examining the impact of Active Video Watching (AVW) on student learning engagement and the overall learning outcome.

The AVW-Space system was designed to investigate the efficacy of teaching soft skills with AVW technique (Mitrovic et al., 2017). This platform exploits students’ familiarity with commenting on videos on social media platforms (such as YouTube and Facebook) and couples interactive notetaking during video watching to encourage student engagement with learning content (videos) and self-reflective learning. AVW-Space allows instructors to create a space by embedding YouTube videos directly into the platform. Previous studies have demonstrated the effectiveness of AVW-Space in teaching presentation skills (Mitrovic et al., 2019).

Therefore, this PhD project expands on the communication instruction approaches generally employed in SE programs to include AVW pedagogy as a novel approach to improve the face-to-face meeting communication performance of SE students.

2. Proposed Research Work

The first goal of the PhD project was to develop an instrument to measure face-to-face meeting communication skills of SE students. According to Huang & Lin (2018), there are numerous reasons why new measurement tools for communication skills are desirable in this modern age. Firstly, the authors argue that most existing communication assessments instruments are outdated, and since communication practices evolve with the change of time, more modern assessment tools are needed to assess communication skills in this new era of globalisation. Secondly, they highlight that little is known about the factor structure of the existing tools, so the validity and utility of these measures are questionable. Lastly, to quickly diagnose issues pertaining to communication competence of students, an assessment tool is desirable so that educators can pay specific attention to the exact aspect of students’ communication competence that needs further attention (Huang & Lin, 2018). Thus, the first objective of this study is to develop an instrument to measure face-to-face meeting communication skills of SE students, and examine the internal consistency and reliability of the developed tool. This phase was guided by the following research questions:

**RQ 1.1.** What are the primary constructs of the instrument that can measure face-to-face meeting communication skills of SE students?

**RQ 1.2.** What is the content validity related evidence that the items developed are a valid measure of face-to-face meeting communication skills of students?

**RQ 1.3.** What are the internal consistency related evidence that the items developed are a reliable measure of face-to-face meeting communication skills of SE students?

**RQ 1.4.** What is the construct validity related evidence that the items developed are a valid measure of face-to-face meeting communication skills of SE students?

The second goal of this project is to investigate the effectiveness of using AVW-Space to teach face-to-face communication skills that SE students employ during meetings. This phase was guided by the following research question:

**RQ 2.** What are the learning outcomes of using AVW-Space to teach face-to-face meetings communication skills?

This project also aims to contribute to scholarship in the area of Technology-Enhanced Learning. We classify students based on their overt behaviour in AVW-Space using the ICAP framework (Chi & Wylie, 2014) into four learning modes: Interactive, Constructive, Active and Passive. Interactive learning mode requires dialogs between the student and peers or instructors, and is the most beneficial in terms of educational outcomes. The key idea is that interactivity needs to involve a substantial level of turn-taking to co-create a common understanding of the learning content. Interactivity is not currently supported in AVW-Space. Hence, in this project, we will extend AVW-Space to facilitate interactive learning. The following research questions will guide this phase:

**RQ 3.1.** To what extent does the proposed intervention scaffold interactive learning behaviours in AVW-Space?

**RQ 3.2.** To what extent does the proposed intervention improve the face-to-face meeting communication skills of SE students?
3. Pilot Study

The pilot study was conducted to address RQ1.1-RQ1.4. We used a deductive approach in the initial phase of scale development to produce research-informed theoretical definitions of face-to-face meeting communication skills. After several reviews of the preliminary scale, we chose 25 items measuring four themes based on the recommendations from discipline experts (software engineering practitioners) and collective agreement by the research group. A pilot study was conducted in August 2020 to evaluate the items and examine the factor structure and internal consistency of the developed scale.

The pilot study was conducted with 111 students SE courses, who were invited by email to complete a Qualtrics survey, which included demographic information, a group assignment scenario and the preliminary scale items. The participants were advised that the scale would measure their face-to-face meeting-related behaviours. The participants were asked to rate the level that describes their typical behaviour during a meeting with a series of statements using a 7-point Likert scale, ranging from 1 (never) to 7 (always). Since the objective of the pilot study was also to identify any issues with item clarity, participants were provided with a space for feedback on the scale items. The participants were instructed to discuss issues with any of the items and suggest alternative wording or structure for confusing or unclear items. All participants were informed that their responses would be confidential.

The preliminary findings of the pilot study identified two items that the participants had issues with clarity and comprehensibility. Therefore, these items were removed from the scale before the factor structure was analysed. For example, for the question “I do not refer to non-technical concepts that may confuse other meeting participants,” participants’ comments included: “The question is ambiguous due to double negative and the term non-technical. Could not totally understand it, hence neutral.” and “I found the question more difficult to understand. I interpreted it as if I DO refer to tech concepts then this is Never and if I DON’T then this is Always”. Also, there were some suggestions to rephrase this item “I listen to the other meeting participants, paying attention to her/his body language” and the question was reworded to “I pay attention to the other meeting participants body language”. In total, 23 items remained following the pilot test and further data collection is needed for the next step of the evaluation.

4. Study One

Figure 1 shows an overview of Study 1, which focuses on RQ2. The study took place at the University of Canterbury in a SE project-based course with 56 students. The students worked in teams of 4 to 6 students, and had weekly face-to-face meetings to discuss the progress. The students were invited to participate in the study in July 20, 2020. We administered a profile survey consisting of three sections: demographic questions, prior conceptual knowledge, and the self-assessment instrument. After the completion of the survey, the participants watched and commented on ten short videos (2 to 6 minutes long) pertaining to effective communication skills for meeting participation on the AVW-Space platform. Six of these videos were tutorials on effective communication skills concepts; four videos were example of real meetings.

![Figure 1. Overview of different tasks in Study 1.](image-url)

Participants could stop a video at any time, enter a comment and select an aspect to indicate the intention of the comment (example of aspects “I am rather good at this”, “I did/saw this in the past”, “I didn’t realise I wasn’t doing this” and “I like this point”). For the example videos, the aspects correspond to effective communication skills covered in the tutorials, which include, “Verbal communication”,

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“Giving feedback”, “Receiving feedback”, “Active listening” and “Meeting contribution”. In phase 2, the authors screened comments for content and select comments that were visible to all participants. Participants were instructed to review and rate the anonymised comments based on the specified categories (such as “I did not notice this”, “I do not agree with this”, “This is useful for me”, “I like this point” and “I hadn’t thought of this”). In the third phase, each team had their weekly meeting recorded and uploaded to AVW-Space. The members of each team then watched the recording of their meeting and commented on their own meeting, and later rated the comments written by their peers in the same team. At the end of these tasks, invitations to complete Survey 2 were emailed on August 20, and the survey was closed on August 27 2020. The preliminary results show that out of 56 students enrolled in the course, 49 completed Survey 1. Of those, 47 have used AVW-Space, while the remaining two participants were inactive learners.

5. Future Work

The future work will include analyzing data collected in Study 1, and then exploratory research to determine and develop an intervention to facilitate effective interactive learning in AVW-Space. We will extend AVW-Space to support interaction between students. Study 2 will contain one group of randomly selected students working with the new version of AVW-Space (experimental group), and another group of students working with the standard version of AVW-Space (control). The data will be quantitative and will be collected through the student logs of AVW-Space and pre- and post-questionnaires (the same ones used in Study 1).

References


Assisting Vocabulary Acquisition and Script Writing Skills Using Mobile-based Kapampangan Intelligent Tutoring System

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Abstract: The popularity of intelligent language tutoring system is gaining traction worldwide but very few studies were actually conducted towards its use particularly among indigenous languages that have its own script writing system. In the case of the Philippines, there are more than hundreds of languages being spoken, unique to these is the Kapampangan language – a language that has its own writing system which follows a top-down-left-right writing sequence and uses diacritical marks to change the vowel sounds. This paper intends to develop a mobile-based ITS for Kapampangan language where the needs of the intended users are considered. It also aims to contribute towards the body of knowledge by implementing a quasi-experimental research design to determine the effectiveness and usability of the developed ITS towards enhancing vocabulary acquisition and script writing skills in Kapampangan using spaced repetition algorithm and metaphor as pedagogy. The proposed methodology and framework are also discussed.

Keywords: Kapampangan, indigenous language, intelligent tutoring system, mobile-assisted language learning, script writing skills

1. Introduction

Kapampangans (Kapampangan people) is the 6th largest ethnic group (“Census of Population,” 2010) and the Kapampangan is among the major languages spoken by many Filipinos. It is widely spoken in both Pampanga and southern Tarlac in the Philippines. It is an indigenous language that has a writing system which follows vertical writing (i.e., top to bottom and right to left) (see Figure 1).

Figure 1. “Kapangpåñgan” written using the Kapampangan script

United Nation said that more than one language is dying each month while many more are at risk (UNDESA, 2016). One of these is Kapampangan language, the language is said to be endangered as pointed out by Pangilinan (2009) where he described how it is dying and in terminal decline particularly among highly urbanized cities of Pampanga (including Angeles City). Pangilinan (2019) revealed that this is due to lexical borrowing from Tagalog and the Kapampangan language can be categorized as definitely endangered (Brenzinger et al., 2003). San Andres (2012) also believed that Kapampangan is indeed a dying language and this is due to contributing factors such as disuse of the language in
literature. While Tayag (1985) provide a dire warning about the possible extinction of the language as more Kapampangans transition to Tagalog.

To this date, there are no studies on the use of intelligent tutoring system for Kapampangan vocabulary acquisition and script writing skills. Thus, the study intends to investigate on the effectiveness and usability of the developed intelligent language tutoring system for Kapampangan vocabulary acquisition and script writing skills for first language learners. Specifically, the study attempts to answer the following questions:

1. How may the vocabulary acquisition and script writing skills of the control and experimental groups be described before using the ITS?
2. Is there significant difference between the vocabulary acquisition and script writing skills before the use of ITS?
3. How may the vocabulary acquisition and script writing skills of the control and experimental groups be described after using the ITS?
4. Is there significant difference between the vocabulary acquisition and script writing skills after the use of ITS?
5. How may the level of acceptance of the participants on the use of ITS be described?
6. What are the challenges encountered by the participants on the use of ITS?
7. Based on the findings of the study, what are the implications of the developed ITS in language acquisition?

2. Objectives of the Study

1. To develop an ITS for Kapampangan vocabulary acquisition and script writing skills;
2. To implement the spaced repetition algorithm and metaphor as pedagogy in the proposed ITS;
3. To investigate on the effectiveness of the developed ITS; and
4. To surface the implications of the developed ITS in language acquisition.

3. Proposed Methodology

3.1 Research Framework and Software Development Life Cycle

The study intended to use quasi-experimental research design involving 2 group of participants, the control and experimental (see Figure 3) to determine the effectiveness of the developed mobile-based ITS in in vocabulary acquisition and development of script writing skills. The study also planned to follow the user-centered design approach process in developing the ITS (see Figure 2). The mobile-based ITS will implement a spaced repetition algorithm together with a metaphor as pedagogy. The spaced repetition will be used to automatically adjust the content, exercises, and answer choices within the developed ITS based on their performance while the metaphor as pedagogy will be applied to enhance the pupil’s vocabulary acquisition and script writing skills.

![User Centered Design Process](https://usabilla.com)

Figure 2. User Centered Design Process (usabilla.com)
3.2 Experimentations

The study will be conducted in one public school in Pampanga where Kapampangan is taught. According to the Holy Angel University’s Center for Kapampangan Studies, the Kapampangan language is mostly taught among Grade 1 to 3 pupils. The study will choose Grade 3 pupils as participants of the study to avoid saturation of data. The participants will be chosen based on their general weighted average (GWA) and their exposure to the Kapampangan language. The study will be composed of two experiments, in the first experiment, a pre-assessment will be given to the participants followed by the human teacher teaching both Kapampangan vocabulary and script writing, and will end with post-assessment test. Afterwards, the developed mobile-based Kapampangan ITS will be administered in the second experiment; it will follow the same process except that the mobile-based Kapampangan ITS will replace the human teacher in the first experiment.

3.3 Data Collection and Analysis

The interactions in the mobile-based Kapampangan ITS will be stored in the system in the form of logs. The primary data to be use for analysis will be collected based on the post-assessment exam in both experiments. A \( t \)-test (independent samples) together with descriptive statistics summary will be interpreted and reported. A test of difference will also be implemented towards the two sets of participants to determine if there is a statistically significant difference between their scores. Additionally, a \( p \)-value of 0.05 and 0.95 reliability will be used to determine the significance of the findings.

4. Conceptual Framework

The study intends to adopt Garette’s Five Planes framework which consist of strategy, scope, structure, skeleton and surface (see Figure 4). Through this framework, it aims to develop from bottom to top to provide a better user experience to users.
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