



*The 21st International Conference
on Computers in Education
18-22 November 2013 Bali, Indonesia*

Workshop Proceedings of the 21st International Conference on Computers in Education 2013

Editors:

Seng Chee TAN Ying Tien WU Tri Wintolo APOKO Lung Hsiang WONG
Chen-Chung LIU Tsukasa HIRASHIMA Pudjo SUMEDI Muhammad LUKMA



Supported by:



UHAMKA PRESS

lintasarta



**Workshop Proceedings of the
21st International Conference
on Computers in Education
ICCE 2013**

**November 18, 2013 - November 22, 2013
Bali, Indonesia**



Copyright 2013 Asia-Pacific Society for Computers in Education

All rights reserved. No part of this book may be reproduced, stored in a retrieval system, transmitted, in any forms or any means, without the prior permission of the Asia-Pacific Society for Computers in Education.

ISBN 978-602-8040-71-6

Publisher:

UHAMKA Press,

Jl Gandaria IV, Kramat Pela,

Kebayoran Baru, Jakarta Selatan,

Indonesia.

Publisher



Jl. Gandaria IV, KramatPela, KebayoranBaru, Jakarta SelatanTelp. (021) 7398898/ext: 112
Website: www.uhamkاپress.com, E-mail: uhamkاپress@yahoo.co.id

12 November 2013

Editors

Seng Chee TAN

Ying-Tien WU

Tri Wintolo APOKO

Lung-Hsiang WONG

Chen-Chung LIU

Tsukasa HIRASHIMA

Pudjo SUMEDI

Muhammad LUKMAN

PREFACE

Established in 1989, International Conference on Computers in Education (ICCE) is now an annual international conference organized by the Asia-Pacific Society for Computers in Education, and has become a major event for scholars and researchers in the Asia-Pacific region to share ideas and discuss their work in the use of technologies in education. This volume contains the supplementary proceedings of the 21st International Conference on Computers in Education (ICCE2013; <http://icce2013bali.org/>) held from November 18 to November 22, 2013 in Denpasar Bali, Indonesia.

This year, we accepted 16 proposals -- 13 workshop, two interactive events, and one tutorial. Each proposal was peer-reviewed by international reviewers with relevant expertise to ensure high-quality work. These pre-conference events aim to explore focused issues of various themes related to the use of technologies in education. Of the 13 workshops organized by international program committees, 10 are in the mini-conference format and the other three have stronger focus on discussion or interactive components. This proceedings contain mainly papers from the workshops of mini-conference style. We believe that the pre-conference events provide a valuable opportunity for researchers to share their work with the community, and to seek further collaboration to extend their ideas. The papers or events that cover a variety of topics will certainly stimulate more interesting research work in these areas in Asia-Pacific countries and beyond. We hope that readers will find the ideas and findings presented in the proceedings relevant to their research work.

Finally, we would like to thank the Executive Committee of the Asia-Pacific Society for Computers in Education and the ICCE 2013 Program Co-Chairs for entrusting us with the important task of chairing the workshop program, thus giving us an opportunity to work with many outstanding researchers. We would also like to thank the Local Organizing Committee for helping with the logistics of the workshop program.

Workshop Coordination Co-Chairs

Seng Chee TAN, Nanyang Technological University, Singapore

Ying-Tien WU, National Central University, Taiwan

Tri Wintolo APOKO, University of Muhammadiyah Prof. Dr. HAMKA, Indonesia

TABLE OF CONTENTS

Workshop 1: Technology Enhanced Language Learning

1.	From a Perspective on Foreign Language Learning Anxiety to Design an Affective Tutoring System <i>Ching-Ju CHAO, Hao-Chiang Koong LIN</i>	1
2.	Learner Attitude and Satisfaction in Chinese Vocabulary Learning under CALL <i>Hong-Fa HO & Jing-Jenq WU</i>	9
3.	The Effect of Learning Community for Game-Based English Learning <i>Chih-Hung LAI, Wu-Jiun PENG, Wei-Hsuan Chen, Rong-Mu LIN</i>	19
4.	Effects of the Concept Mapping and Reflection Strategies on Motivations of EFL Learners <i>Ching-Kun HSU</i>	28
5.	Designing a Mobile Chinese Learning System with Speech Recognition for Foreign Students <i>Wei-Tung TANG & Shwu-Ching YOUNG</i>	37
6.	Apples and Oranges? Second Life vs. OpenSim for Language Learning <i>Mark G. ELWELL, Jean-Christophe TERRILLON, and Steven A. COOK</i>	46
7.	A Cooperative Learning Platform for Context-aware Ubiquitous Learning: A Pilot Study of Mandarin Chinese Learning Activities <i>Szu-Yun WANG, Yu-Ju LAN, Yau-Ming YEH, Jen-Shing LIN, Yao-Ting Sung</i>	52

Workshop 2: 4th International Workshop on “Technology-Transformed Learning: Going Beyond the One-to-One Model?”

8.	Bridging the Past and the Future of the Research in Seamless Learning <i>Lung-Hsiang WONG</i>	56
9.	Mobile Supported Flipped Instruction and Learning <i>Wan NG</i>	65
10.	Analysis of Ubiquitous Learning Logs in the Context of Science Communications in a Museum <i>Hiroaki OGATA, Kousuke MOURI, Mayumi BONO, Ayami JOH, Katsuya TAKANASHI, Akihiro OSAKI, Hiromi OCHIAI, Yuko MORITA</i>	74
11.	Developing a Professional Development Model for Science Teachers to Implement a Mobilized Science Curriculum <i>Daner SUN, Chee-Kit LOOI, Yen Lin Jenny LEE, Jessy Pui Shiong NG</i>	80
12.	Enhancing Outside-class Learning using Ubiquitous Learning Log System <i>Noriko UOSAKI, Hiroaki OGATA, Mengmeng LI, Bin HOU, & Kousuke MOURI</i>	90

13. Teacher Thinking and Affordances of TouchPad Technology: An Ongoing Study of Teacher Adoption of iPads in Higher Education 100
Daniel CHURCHILL, Jie LU, & Tianchong WANG

Workshop 3: Application of Innovative Educational Technologies in STEM Education

14. Improving student engagement through a blended teaching method using Moodle 110
Richard LAI, Nurazlina SANUSI
15. Embedding Collaboration into a Game with a Self-explanation Design for Science Learning 116
Chung-Yuan HSU, Feng-Chin CHU & Hung-Yuan WANG
16. The Development and Evaluation of a 3D Simulation Game for Chemistry Learning: Exploration of Learners' Flow, Acceptance, and Sense of Directions 122
Huei-Tse HOU, Shu-Ming WANG & De-Shin TSAI
17. Pre-service teachers' learning and frustrations during the development of serious educational games (SEGs) for learning biology 130
Mei-En HSU, Meng-Tzu CHENG
18. Criteria and Strategies for Applying Concept-Effect Relationship Model in Technological Personalized Learning Environment 136
Patcharin PANJABUREE & Niwat SRISAWASDI
19. The Development and Evaluation of the Science Reading and Essay Writing System 142
Li-Jen WANG, Yu-An CHEN, Chen-Min LAI, & Ruo-Han CHEN, Ying-Tien WU
20. Effect of Simulation-based Inquiry with Dual-situated Learning Model on Change of Student's Conception 147
Niwat SRISAWASDI, Sunisa JUNPHON & Patcharin PANJABUREE
21. Exploring the Effect of Worked Example Problem-based Learning on Learners' Web-technology Design Performance 155
Chun-Ping WU & Hao Jie YONG

Workshop 4: 6th Workshop on Modeling, Management and Generation of Problems/Questions in Technology-Enhanced Learning

22. How to Construct an Assessment System for Engineering Courses 161
Yu-Hur CHOU & Hsin-Yih SHYU
23. Adaptive Question Generation for Student Modeling in Probabilistic Domains 167
Nabila KHODEIR & Nayer WANAS
24. Facilitating Creative Cognition by Embodied Conversational Agents 175
Yugo HAYASHI
25. Preliminary Assessment of Online Student-Generated Tests for Learning 183
Fu-Yun YU

26.	Empirical Study on Errors of Mathematical Word Problems Posed by Learners <i>Kazuaki KOJIMA, Kazuhisa MIWA & Tatsunori MATSUI</i>	187

27.	The Design Principles of the Worked Examples <i>Chun-Ping WU & Pi-Han LO</i>	192

Workshop 5: 3rd Workshop on Skill Analysis, learning or teaching of skills, Learning environments or Training Environments for Skills (SKALTE 2013)

28.	Design of Tennis Training with Shot-timing Feedback based on Trajectory Prediction of Ball <i>Naka GOTODA, Kenji MATSUURA, Koji NAKAGAWA & Chikara MIYAJI</i>	196

29.	Training-Course Design for General Purpose of Motor-Skill Learners on a Web <i>Kenji MATSUURA, Hirofumi INUI, Kazuhide KANENISHI & Hiroki MORIGUCHI</i>	202

30.	Feedback of Flying Disc Throw with Kinect: Improved Experiment <i>Yasuhisa TAMURA, Masataka UEHARA, Taro MARUYAMA & Takeshi SHIMA</i>	209

31.	Electroencephalogram Analysis of Pseudo-Haptic Application for Skill Learning Support System <i>Hirokazu MIURA, Keijiro SAKAGAMI, Yuki SETO, Shumpei AKO Hirokazu TAKI, Noriyuki MATSUDA & Masato SOGA</i>	217

Workshop 7: 2nd International Workshop on ICT Trends in Emerging Economies (WICTTEE)

32.	Exploring Educational Transformation through ICT in Emerging Developing Countries within the Asia-Pacific Region <i>Su Luan WONG, Ahmad Fauzi Mohd AYUB, Mohammad LUKMAN & Chien-Sing LEE</i>	223

33.	Do Teacher Related Factors Play a Role in Laptop Use for Teaching-Learning? <i>Su Luan WONG & Priscilla Moses</i>	225

34.	Classroom Action Research: Using Interactive Learning Media to Improve Students' Colligative Solution Learning Outcome. <i>Yusnidar YUSUF, Endy Syaiful ALIM, Tyas Hermala ANINDITA</i>	231

35.	Increasing Students' Mathematical Creative Thinking Abilities through Realistic Mathematics Education Using ICT and Deduction <i>Miftahul SAKINAH, Sigid Edy PURWANTO</i>	237

36.	Exploring Teachers' Cultural Perception of ICT in Nigerian Schools through a Qualitative Approach <i>Arit Uyouko UYUOKO & Su Luan WONG</i>	243

37.	Factors Affecting ICT Integration among Teachers and Students <i>Ying GUO</i>	252

38.	The Role of Epistemic Agency and Progressive Inquiry in the Transfer of Mathematical Thinking <i>Chien-Sing LEE, Tsung-Chun HO, Ping-Chen CHEN, Tak-Wai CHAN, K. Daniel WONG</i>	258

39. Developing Learning System in Pesantren: The Role of ICT 264
Syaiful ROHIM & Lina YULINDA

Workshop 8: The Application for Information and Communication Technologies in Adult and Continuing Education

40. Exploring the Changes in In-service Teachers' Perceptions of Technological Pedagogical Content Knowledge and Efficacy for ICT Design Thinking 270
Ching Sing CHAI, Joyce Hwee Ling KOH, Pei-Shan TSAI, Normalah ISMAIL & Erwin ROHMAN
41. The Relationships between Child-Parent Shared Mobile Augmented Reality Picture Book Reading Behaviors and Children's cognitive attainment 275
Kun-Hung CHENG & Chin-Chung TSAI
42. Strategies for Leveraging Learning Game Data for Middle School Mathematics Instruction 278
Michael A. EVANS & Jordan PRUETT
43. Examining the effects of integrating technological pedagogical content knowledge into preschool teachers' professional development regarding science teaching: using digital game-based learning as an example 286
Chung-Yuan HSU, Yi-Ching SU, & Jyh-Chong LIANG
42. Development of the Chinese Pre-service Teachers' Technological Pedagogical Content Knowledge Scale 291
Guoyuan SANG, Yan DONG, Ching Sing CHAI & Ying ZHOU
43. Effect of graphic design on E-book reading: A pilot eye-tracking study 298
Tse-Wen PAN, Ming-Chieh Hsu & Meng-Jung TSAI
44. The relationships between master degree students' online academic information search behaviors and online academic help seeking 306
Ying-Ju CHIU & Chin-Chung TSAI
45. Graduate students' online academic information search behaviors in Taiwan 312
Jui-Chi WU & Jyh-Chong LIANG
46. The Relationships between Taiwan University Students' Internet Attitudes and Their Preferred Teacher Authority toward Internet-based Learning Environments 318
Tzung-Jin LIN & Min-Hsien LEE
47. Promoting Second Language Writers' Error Corrections with Corpus: A Case Study 322
Hui-Hsien FENG & Ying-Hsueh CHENG
48. Using Internet as Research Tool: An Example of Meta-Analysis Study 328
Shih-Hsuan WEI
49. Development questionnaire about High school students learning science and technology in the 21st century 332
Chih-Hui LIN & Jyh-Chong, LIANG

50. Exploring the differences of the Internet-specific epistemic beliefs between Taiwanese undergraduates and high school students 340
Yen-Lin CHIU & Chin-Chung TSAI

Workshop 9: Enhancing Learning through Digital Games & Intelligent Sensor Toys

51. The Effect of Challenging Game on Students' Motivation and Flow Experience in Multi-touch Game-based Learning 345
Cheng-Yu HUNG, Chih-Yuan Jerry SUN & Pao-Ta YU
52. Learning Application with Collaborative Finger-Touch Game-Based Learning - A Study of iPad app in Mathematics Course 353
Cheng-Yu HUNG, Chih-Yuan Jerry SUN & Pao-Ta YU
53. A Courseware Developed with Toy-like Interactive Interfaces 378
Ping-Lin FAN, Hsueh-Wu WANG, Su-Ju LU, Chi-Shan YU & Wei-Hsien WU
54. Investigating Students' Sequence of Mathematical Topics in an Educational Game with a Curriculum Map 361
Hercy N.H. CHENG, Charles Y.C. YEH, Hui-Wen WU, Calvin C.Y. LIAO, Andrew C.-C. LAO & Tak-Wai CHAN
55. Tailored RPG as a Supplementary Reading Pedagogy for Teaching English 367
Mira Luxita SARI & Cheng-Ting CHEN
56. The Interactive Building Projection on Heritage Based on Game-Based Learning—A Case of “Red Building in National University of Tainan” 373
Wen-Lin HONG, Yi-Hsin CHANG, Hen-Yi CHEN & Hao-Chiang Koong LIN
57. The Evaluation Framework for the Group Development Process of Adventure Education Game 379
Chang-Hsin LIN, Ju-Ling SHIH, & Yu-Jen HSU
58. The Instructional Application of Augmented Reality in Local History Pervasive Game 387
Jyun-Fong GUO, Ju-Ling SHIH
59. Designing a Farming Game with Social Design to Support Learning by Reciprocal Questioning and Answering 394
Yih-Ruey JUANG

Workshop 10: Innovative Design of Learning Space

60. The effect of the Mozart music on learning anxiety and reading comprehension on Chinese storybook reading 399
Yen-Ning Su, Chia-Cheng Hsu, Chia-Ju Liu, Yueh-Min Huang & Yu-Lin Jeng
61. Using Augmented Reality to Assist an Interactive Multi-Language Learning System in an Elementary School 404
Gwo-Haur HWANG, Chen-Yu LEE, Hen-Lin HWANG, Guan-Lin HUANG, Jheng-Yi LIN & Jun-Jie CAI

62.	A Study of Pragmatics Applied to Teacher – Parent Communication <i>Ching-Feng CHEN, Cong-Xun XIE, Shein-Yung CHENG, Wen-Yi Zeng, Wei-Fu Huang & Jia-Sheng HEH</i>	412
63.	Enhancing Learning Achievement Using Affective Tutoring System in Accounting <i>Ya-Ping HSUEH, Hao-Chiang Koong LIN & Meng-Shian OU</i>	421
64.	Evaluating the Users' Continuance Intention and Learning Achievement Toward Augmented Reality e-Learning with User Experience Perspective <i>Yu-Ling LIU, Po-Yin CHANG & Chien-Hung LIU</i>	427
65.	Establishing an Innovative Plant Learning Platform with Expandable Learning Materials Using Wiki Software <i>Shu-Chen Cheng, Chien-Ming Shao</i>	434

Workshop 12 Preface: Computer-Supported Personalized Learning

66.	Development and Evaluation of a Problem Solving Oriented Game-Based Learning System <i>Hsin-Yi LIANG, Song-Yu MEI, Yu-Syuan WANG, Jih-Liang JIANG, Gwo-Haur HWANG & Chen-Yu LEE</i>	440
67.	Planning and Design of Personalized Dynamic Assessment for Linux Learning <i>Hsin-Chih LIN and Cheng-Hong LI</i>	449
68.	Personalized Game-based Learning and Mobile Learning: The App Game “The Adventure of The Ch’ing Dynastry Treasures” <i>Sheng-Chih CHEN, Po-Sheng TIEN, Yi-Chin YANG, Fu- Hsin PENG, Kuan-Ying WU, Wei-Lin CHEN, & Yi-Jia HUANG</i>	455
69.	Learning Experience of Game Poetry: A New Approach for Poetry Education <i>Hsin-Yi LIANG & Sherry Y. CHEN</i>	463
70.	Students' Motivation of Science Learning in Integrated Computer-based Laboratory Environment <i>Niwat SRISAWASDI, Rungtiwa MOONSARA & Patcharin PANJABUREE</i>	472
71.	Guideline for the Development of Personalized Technology-enhanced Learning in Science, Technology, and Mathematics Education <i>Patcharin PANJABUREE & Niwat SRISAWASDI</i>	480
72.	Stimulating Self-Regulation for High and Low Achievers in a Self-Directed Learning Environment <i>Andrew C.-C. LAO, Mark C.-L. HUANG & Tak-Wai CHAN</i>	488
73.	Cognitive Styles and Hybrid Mobile Systems <i>Chen-Wei HSIEH & Sherry Y. CHEN</i>	496

Workshop 13 Preface: Scaling up collaborative innovation for ICT in Education

74.	Collaborative Problem-Solving Learning Supported by Semantic Diagram Tool: From the View of Technology Orchestrated into Learning Activity <i>Huiying CAI, Bian WU & Xiaoqing GU</i>	504

75. Comparative Research of ICT in Elementary Education Development Strategy in Developed and Developing Countries 512
Chun LU, Sha ZHU&Di WU
76. Diffusion of ICT in Education: Behavior Subjects, Dynamic Diffusion Model and Enhance Methods 521
Jinbao ZHANG

From a Perspective on Foreign Language Learning Anxiety to Design an Affective Tutoring System

Ching-JuCHAO^{ab*}, Hao-Chiang KoongLIN^a

^aDept. of Information and Learning Technology, National University of Tainan, Taiwan

^bDept. of Applied Foreign Languages, Tung Fang Design Institute, Taiwan

*chingju@mail.tf.edu.tw

Abstract: According to Krashen's affective filter hypothesis, students who are highly motivated have a strong sense of self, enter a learning context with a low level of anxiety, and are much more likely to become successful language acquirers than those who do not. Affective factors, such as motivation, attitude, and anxiety, have a direct impact on foreign language acquisition. Horwitz et al. (1986) mentioned that many language learners feel anxious when learning foreign languages. Thus, this study recruits 100 college students to fill out the Foreign Language Classroom Anxiety Scale (FLCAS) to investigate language learning anxiety. Then, this study designs and develops an affective tutoring system (ATS) to conduct an empirical study. The study aims to improve students' learning interest by recognizing their emotional states during their learning processes and provide adequate feedback. It is expected to enhance learners' motivation and interest via affective instructional design and then improve their learning performance.

Keywords: Foreign Language Learning Anxiety, Affective Filter Hypothesis, Affective Tutoring System, Japanese Learning

1. Introduction

The learning process of learning a second language is not always smooth and successful for many people. In recent years, the study of second language acquisition towards exploring learner's personality factors has been a trend, in addition to the language acquisition process and teaching methods. Chaudron, C.(2001) analyzed studies published in *The Modern Language Journal*, between 1916 and 2000. He referred to the 1980s as a period of learner-centered learning and mentioned an increasing trend towards research into the relevance of learners' psychology. In the past, language acquisition research focused on the study of what characteristics are possessed by successful language learners. Learning outcomes of the same teaching methods would not be the same for all learners in the same learning context; thus, personality factors should be incorporated into second language acquisition theories. Brown (2006) also stated that understanding how people feel, respond, and evaluate is a very essential part of second language acquisition theories.

Horwitz, Horwitz, and Cope (1986) mentioned that many learners feel anxious when learning foreign languages. In Krashen (1988) Affective Filter Hypothesis, the affective filter is likened to an invisible wall which exists between learners and languages. Factors, such as negative attitudes and insufficient learning motivation or enthusiasm, form a filter which hinders learner's message reception and comprehension, and then affects outcomes of second language learning. In other words, when learners feel bored, tired, nervous, or anxious or have no energy, they screen out learning content and then cannot fully learn materials which have been taught. According to this hypothesis, learner's mood and attitude determine the quality of learning.

Learning efficiency would be reduced when fear, anxiety, and other negative emotions appear, whereas positive emotions enhance learning outcomes.

Therefore, this study recruits 100 college students who are Japanese language learners to fill out the Foreign Language Classroom Anxiety Scale (FLCAS) and uses an Affective Tutoring System (ATS) in which the participants are allowed to learn Japanese language in a less stressful context which can enhance their motivation and improve their learning outcomes. The ATS can identify learners' emotions, select appropriate lessons for the learners based on their abilities, offer appropriate learning strategies, and provide affective feedback. The aforementioned characteristics of the ATS can reinforce learners' positive emotions, improve negative moods, and then enhance motivation which would promote learning effectiveness and help students recognize their achievements.

2. Literature Review

Affective Factors in Second Language Acquisition (SLA)

Arnold (1999:8) mentioned that “anxiety is quite possibly the affective factor that most pervasively obstructs the learning process. It is associated with negative feelings such as uneasiness, frustration, self-doubt, apprehension and tension.” Mori and Mori (2011) indicated that research on individual differences in second language acquisition (SLA) confirms that some non-linguistic factors can explain why some second language learners are more successful than others. These individuals’ differences may come from affective factors, including motivation, anxiety, attitudes, and learner perceptions. Many affective studies examined different strategies employed by learners with various goals, feelings, attitudes, and perceptions when they encounter the same task and investigated how these approaches affect the levels of success in language learning. Mori and Mori (2011) believed that the two aspects in the study of affective factors are to examine the relationship between the known variables and learning behaviors using large scale quantitative data and to carry out a more in-depth study of individual learners.

Brown (2006) mentioned that personal factors include language learning strategies, learning styles, affection, self-confidence, beliefs, motivation, ages, and socio-cultural factors. Personal factors, which also have direct impacts on learning effectiveness, are often very complicated and interrelated. When given the same lessons in the same learning environment, learners’ results vary. High achievers are capable of finding and using strategies without being specifically instructed. However, low achievers who lack motivation would need more guidance.

Oxford (1990) also believed that the influence of affective factors in language learning is very important. Affective factors include emotions, attitudes, motivations, and values. Language learners can use affective strategies to control these factors. The affective strategies proposed by Oxford (1990) stabilize learners’ emotions, including lowering anxiety, self-encouragement, and taking one’s emotional temperature. Good language learners are usually those who know how to control their learning emotions and attitudes (Naiman et al, 1975). However, Chamot et al. (1987) stated that not many studies have examined the frequency of using affective strategies, and approximately 1 of 20 learners employs affective strategies.

Affective filter hypothesis

One of the five hypotheses (Krashen, 1987) concerning second language acquisition is the “affective filter”, which acts like an invisible wall between learners and input, interfering with and limiting the delivery of language input. For example, those students who lack motivation are likely to pay less attention to the input; their filter level is high, so less input can reach them. On the other hand, highly motivated learners concentrate on the language input which penetrates their language acquisition device as a result. Thus, according to Krashen’s (1987) hypothesis, passive attitudes and lack of motivation and enthusiasm in learning are regarded as a filter which impedes learners’ response to language input and thus affects the learning effectiveness. When learners are bored, nervous, and stressed or lack motivation, their screen will be raised which would result in the incapability to process learning content. Learners’ feelings and attitudes are critical factors in the quality of learning. When negative feelings, such as fear and shyness, are at a low level, learning efficiency increases and vice versa.

The affective filter hypothesis states that affective factors influence second language learning, especially the speed of learning, not the path and direction. Krashen (1987) believed that the affective filter increases after learner’s puberty. Adults have more self-consciousness and different emotions which lead to differences in second language learning and first language acquisition. So the process of language acquisition is not related to age differences; adults who have less success in language learning mostly are due to affective factors and not their ages.

Research in Foreign Language Anxiety

The lack of a reliable and effective method to evaluate learners’ foreign language learning anxiety; therefore, research on relationships between learning anxiety and foreign language learning has not been extensively studied (Scovel, 1978; Horwitz et al., 1986). With this view of language anxiety, Horwitz et al. (1986) developed the Foreign Language Classroom Anxiety Scale (FLCAS) as a 33-item instrument scored based on a 5-point Likert-type scale, from “strongly agree” to “strongly disagree.” This instrument was used to measure foreign language learners’ anxiety level while learning a language in a classroom. The higher the score is, the higher the anxiety level would be. Horwitz (1986) performed the internal consistency reliability analysis of 108 samples, and Cronbach’s Alpha coefficient reached .93. MacIntyre & Gardner (1991) stated that foreign language anxiety is a risky element which can interfere with the acquisition, retention, and language output. Moreover, Aida (1994) conducted a research on Japanese language learners according to Horwitz et al.’s (1986) three-factor model of foreign language anxiety (FLA) and obtained the internal consistency of .94, using Cronbach’s alpha coefficient. Although foreign language anxiety has been considered an important factor that affects the effectiveness of language learning, results of different studies are used to develop various factor models. Horwitz et al. (1986) proposed the foreign language classroom anxiety scale (FLCAS) which has three domains: communication apprehension, test anxiety, and fear of negative evaluation. However, Aida’s (1994) study stated that the FLCAS is a four-factor model: speech anxiety, fear of negative evaluation in the Japanese class, degree of comfort when speaking with native speakers of Japanese, and negative attitudes towards the Japanese class. In Aida’s (1994) study, six items (items 2, 6, 15, 19, 28 and 30) were removed from the final model. However, the result shows the foreign language learning anxiety is negatively correlated to students’ performance in language learning.

3. Research Method

3.1 Research Architecture

This study aims to analyze language learning anxiety of Japanese language learning and its causes from the perspectives of foreign language learning anxiety and affective filter hypothesis. This study uses the affective tutoring system in which the system agent can identify the learners' emotions by their facial expression and written words, offer feedback to reduce their anxiety level, and thus enhance learning effectiveness. This is an empirical study to evaluate and verify the usability of the proposed system and participants' learning effectiveness and then conclude that technology could enhance language learning. Figure 1 shows the research framework of this study.

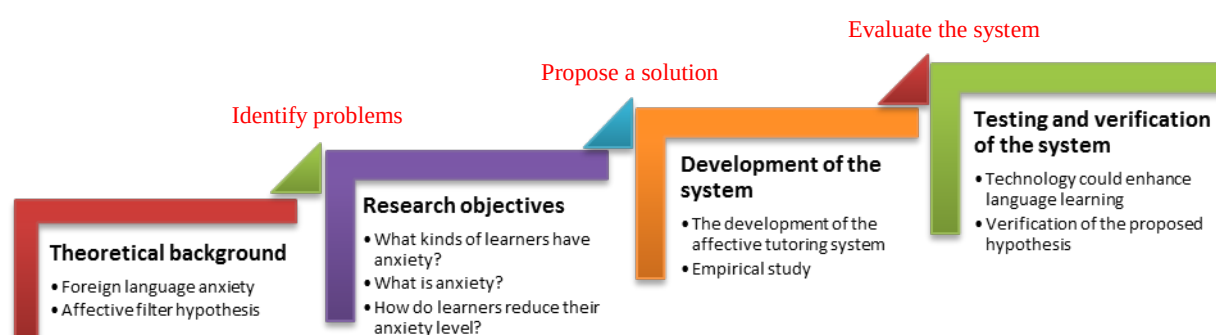


Figure 1. Framework of this study

3.2 Participants

This study uses Horwitz et al.'s (1986) Foreign language class anxiety scale (FLCAS) as an instrument to evaluate learning anxiety of the 100 college students who are Japanese language learners in Taiwan. Those participants are classified as 60 beginners and 40 nonbeginners according to their foreign language level. Sixty-four of them major in language studies, and the rest of them major in other studies. Twenty-six of them are males, and the rest of them are females. Thirteen out of the 100 participants has taken the Japanese Language Proficiency Test (JLPL), and they are all females. Thirty-five out of the 100 participants in which 19 of them with a language major and 16 of them with a non-language major participate in the empirical study and use the affective tutoring system (ATS). The details of the empirical study will be discussed in another study.

Instrument

This study uses the FLCAS as an instrument to evaluate the participants' learning anxiety level and uses Horwitz et al.'s (1986) three-factor model and Aida's (1994) four-factor model to analyze the collected data.

The development of the affective tutoring system (ATS) is based on Horwitz et al.'s (1986) three-factor model with consideration of communication apprehension, test anxiety, and fear of negative evaluation. The ATS-JP uses the agent to substitute a real teacher and appropriately provides the learners affective feedback, including words, pictures, voice, and curriculum adjustments, with an aim to improve the learners' test anxiety by offering repetitive practices and lowering their communication apprehension and fear of negative evaluation which may occur in a physical classroom.

In this study, the affective tutoring system (ATS) is designed to provide basic Japanese lessons. The Affective Japanese tutoring system (ATS-JP) can recognize the learners' facial expression

and emotional states and then offer them appropriate lessons with three different grades of difficulty: simple, normal, and advanced. During the course, the system monitors the learners' emotional states, gives positive feedback, and adjusts the curriculum accordingly. Figures 2 and 3 show the ATS-JP interfaces of simple class and normal class.



Figure 2 : Simple class



Figure 3 : Normal class

4. Experimental results

The FLCAS contains 33 items and employs a 5-point Likert-type scale scored on a continuum ranging from “strongly agree (5)” to “strongly disagree (1)”. Possible scores on the FLCAS range from 33 to 165 with a hypothetical mean of 99. The higher the score is, the higher the level of foreign language anxiety would be. The statistical results show that the learners who receive scores above 99 are more than half of the class (55) with an average score of 102.9. Table 1 shows the results of this study compared to Horwitz et al's (1986) and Aida's (1994) studies.

Table 1 The results of this study compared to Horwitz et al.'s (1986) and Aida's (1994) studies

	Present Study	Horwitz's Study	Aida's Study
Sample size	100	108	96
Foreign language	Japanese	Japanese	Spanish
Student's FL level	Major / Beginners(24) Non- Major / Beginners(36) Major / Non-Beginners(40)	Beginners	Beginners
Score range	45-161	45-147	47-146
Mean	102.9	94.5	96.7
Standard deviation	22.4	21.4	22.1

Anxiety is classified into five levels according to Krinis (2007) (See Table 2). Tables 3 to 5 provide descriptive results of this study. The results show that 52 % of the non-major/beginners tend to have high anxiety, and 53% of the major/ non-beginners have high anxiety. The male participants (54%) have high anxiety. The 54% of the participants who haven't taken the JLPT tend to have anxiety, and the 38% of those who have taken the JLPT have very low anxiety. The results indicate that the learners who have more confident in a target language do not tend to have anxiety.

Table 2: Level of Foreign Language Anxiety (quoted by Dr. Anna Krinis(2007))

Scores	Level of Foreign Language Anxiety	Level
33-82	Very low anxiety	1
83-89	Moderately low anxiety	2
90-98	Moderate anxiety	3
99-108	Moderately high anxiety	4
109-165	High anxiety	5

Table3: Level of Foreign Language Anxiety (Student's FL level)

Number of the participants/ percentage	Very low anxiety	Moderately low anxiety	Moderate anxiety	Moderately high anxiety	High anxiety	Total
Major/Beginners(24)	5 / 21%	4 / 17%	4 / 17%	6 / 25%	5 / 21%	24 / 100%
Non-Major/Beginners(36)	6 / 17%	2 / 6%	9 / 25%	7 / 19%	12 / 33%	36 / 100%
Major/Non-Beginners(40)	6 / 15%	2 / 5%	7 / 18%	4 / 10%	21 / 53%	40 / 100%
Total	17 / 17%	8 / 8%	20 / 20%	17 / 17%	38 / 38%	100 / 100%

Table4: Level of Foreign Language Anxiety (Gender)

	Very low anxiety	Moderately low anxiety	Moderate anxiety	Moderately high anxiety	High anxiety	Total
Male	2 / 8%	1 / 4%	5 / 19%	4 / 15%	14 / 54%	26 / 100%
Female	15 / 20%	7 / 9%	15 / 20%	13 / 18%	24 / 32%	74 / 100%
Total	17 / 17%	8 / 8%	20 / 20%	17 / 17%	38 / 38%	100 / 100%

Table5: Level of Foreign Language Anxiety (Experience of taking the JLPT)

	Very low anxiety	Moderately low anxiety	Moderate anxiety	Moderately high anxiety	High anxiety	Total
Haven't taken the JLPT	12 / 14%	8 / 9%	19 / 22%	15 / 17%	33 / 38%	87 / 100%
Have taken the JLPT	5 / 38%	0 / 0%	1 / 8%	2 / 15%	5 / 38%	13 / 100%
Total	17 / 17%	8 / 8%	20 / 20%	17 / 17%	38 / 38%	100 / 100%

Tables 6 and 7 show the results of this study which are analyzed based on Horwite et al's (1986) and Aida's (1994) factor models. The mean value (3.36) of communication apprehension indicates the main source of language anxiety, and the mean value (3.52) of comfortableness with Japanese indicates that the participants tend to have more anxiety in the context of talking with native Japanese speakers.

Table6: The results analyzed based on Horwitz et al.'s (1986) factor model

Horwitz's factor model	Communication Apprehension	Test Anxiety	Fear of Negative Evaluation
Major/Beginners(24)	2.95	2.82	2.85
Non-Major/Beginners(36)	3.31	3.12	3.26
Major/Non-Beginners(40)	3.36	3.02	3.23
Average	3.24	3.01	3.11

Table7: The results analyzed based on Aida's(1994) factor model

Aida's factor model	Speech Anxiety	Fear of Failing	Comfortableness with Japanese	Negative attitude
Major/Beginners(24)	2.85	3.05	3.15	2.6
Non-Major/Beginners(36)	3.23	3.00	3.22	2.68
Major/Non-Beginners(40)	3.26	3.19	3.52	2.74
Average	3.15	3.09	3.32	2.69

Figure 4 shows photos of the experimental process. There are 35 participants who use the ATS and complete the pretest, posttest, the system usability scale and then learning motivation scale. The participants' feedback indicates that the ATS has high usability. The results of the pretest, posttest, and the learning motivation scale indicate that the ATS is beneficial for the Japanese language learning, reducing learning anxiety, and improving learning effectiveness effectively.



Figure 4 Photos of the experimental process

5. Conclusions and implications

The results of this study indicate that half of the participants have language learning anxiety. However, there is no significant correlation between learning anxiety and language beginners or students with a Japanese language major, indicating that anxiety could occur in any language learning process. The male participants who account for 54 % of the participants tend to have high language learning anxiety, and 77% of the participants who have not taken the JLPT tend to have anxiety, indicating that those who have taken the JLPT would have higher self-esteem and less anxiety in learning Japanese. In addition, the results show that students tend to experience language anxiety in communication situations. The participants would have more anxiety in the context of talking with native Japanese speakers. The ATS-JP uses the agent to substitute a real teacher, detects the learners' emotions, and provides feedback appropriately, including words, pictures, voices, and curriculum adjustments, with an aim to improve the learners' test anxiety by offering repetitive practices and lowering their communication apprehension and fear of negative evaluation which may occur during learning a language in a physical classroom. Moreover, the ATS-JP provides opportunities for the learners to practice repetitively to improve test anxiety and enhance comfortableness with Japanese.

The ATS-JP is still in an experimental phase, and more emotional identification methods would be proposed to improve the recognition accuracy in the future. In addition, other algorithms would be adopted to improve the system's ability to recognize learners' emotional states from text input. Another goal is to integrate voice functions into the system to provide speaking practices to assist students who are shy of talking to have more practice opportunities with an aim to learn in an easy and stress-free language learning context.

References

- Aida, Y. (1994). Examination of Horwitz, Horwitz, and Cope's construct of foreign language anxiety: The case of students of Japanese. *The Modern Language Journal*, 78(2), 155-168.
- Ammar, M. B., Neji, M., Alimi, A. M., & Gouardères, G. (2010). The Affective Tutoring System. *Expert Systems with Applications* 3013-3023.

- Arnold, J., & Brown, H. D. (1999). 1 A map of the terrain. *Affect In Language Learning*, 1.
- Brooke, J. (1996). SUS: A quick and dirty usability scale. In Jordan, P., Thomas, B., Weerdmeester, B., & McClelland, I. (Eds.), *Usability evaluation in industry*. 189-194. London: Taylor & Francis.
- Brown, H. D. (2006) *Principles of Language Learning and Teaching* (5th Edition) Pearson ESL.
- Chamot, A. U., O'Malley, J. M., & Impink-Hernandez, M. V. (1987). *A study of learning strategies in foreign language instruction: first year report*. Rosslyn, VA: interstate Research Associates.
- Chaudron, C. (2001) *Progress in Language Classroom Research : Evidence from The Modern Language Journal*, 1916-2000. *The Modern Language Journal*, 85, 57-76.
- Dowling, W. J. (1993). Procedural and Declarative Knowledge in Music Cognition and Education, in Tighe, T. J. and Dowling, W. J. (eds.), *Psychology and Music: The Understanding of Melody and Rhythm*, Hillsdale, N.J.: Lawrence Erlbaum Associates, pgs. 5-18.
- Ekman, P., & Friesen, W. V. (1971). Constants across cultures in the face and emotion. *Journal of Personality and Social Psychology*, 17(2), 124-129.
- Gardner, R. C. & Lambert, W. E. (1985). *Attitudes and motivation in L2 learning*. Rowley, MA: Newbury House.
- Giles, M. M. (1991). A Little Background Music Please. *Principal Magazine*, 41-44.
- Graesser, A. C., D'Mello, S., & Person, N. K. (2009). *Metaknowledge in tutoring*. Mahwah, NJ.: Taylor & Francis.
- Horwitz, E. K., Horwitz, M. B., & Cope, J. (1986) *Foreign Language Classroom Anxiety*. *Modern Language Journal*, 70(2), 125-132.
- Jensen, E. (1998). *Teaching with the Brain in Mind* Association for Supervision & Curriculum Deve
- Koedinger, K. R., & Corbett, A. (2006). *Cognitive tutors: technology bringing learning science to the classroom*. New York: Cambridge University Press.
- Kort, B., Reilly, R., & Picard, R. (2001). An affective model of interplay between emotions and learning: Reengineering educational pedagogy building a learning companion. Paper presented at the IEEE international conference on advanced learning technology: Issues, achievements and challenges.
- Krashen, Stephen D. (1988) *Second Language Acquisition and Second Language Learning*. Prentice-Hall International.
- Krashen, Stephen D. (1987) *Principles and Practice in Second Language Acquisition*. Prentice-Hall International.
- Krins, A. (2007). *Foreign Language Anxiety*. Retrieved June 20, 2013, from the World Wide Web at <http://www.docstoc.com/docs/75937991/PRAKTIKA---FOREIGN-LANGUAGE-ANXIETY>
- Kurahachi, Junko. (1991) A study of affective factors in a foreign language learning. *Studies in sociology, psychology and education*. 33, 17- 25.
- MacIntyre, P. D., & Gardner, R. C. (1991). *Language Anxiety: Its Relationship to Other Anxieties and to Processing in Native and Second Languages**. *Language learning*, 41(4), 513-534.
- Mao, X., & Li, Z. (2009). *Implementing Emotion-Based User-Aware E-Learning*. CHI, Boston, MA, USA.: Spotlight on Works in Progress.
- McGinn, L., Stokes, J., & Trier, A. (2005). Does music affect language acquisition? Paper presented at TESOL, San Antonio, TX.
- Mitrovic, A., McGuigan, N., Martin, B., Suraweera, P., Milik, N., & Holland, J. (2008). *Authoring constraint-based tutors in ASPIRE: a case study of a capital investment tutor*. Paper presented at the World Conference on Educational Multimedia, Hypermedia and Telecom-munications, AACE, Chesapeake, VA.
- Mori, Y., & Mori, J. (2011). A Language in Focus - Review of recent research (2000-2010) on learning and instruction with specific reference to L2 Japanese. . *Language Teaching*, 44(4), 447-484. doi: <http://dx.doi.org/10.1017/S0261444811000292>
- Naiman, N., Frohlich, M., & Todesco, A. (1975). The good second language learner. *TESL Talk*, 6(1), 58-75.
- Oxford, R. L. (1990). *Language learning strategies: What every teacher should know*. New York: Newbury House.
- Picard, R. (1997). *Affective computing*. . Cambridge, MA.: The MIT Press.
- Pintrich, P. R., Smith, D. A. F., Garcia, T., & Mckeachie, W. J. (1993). Reliability and predictive validity of the Motivated Strategies for Learning Questionnaire (MSLQ). *Educational and Psychological Measurement*, 53, 801-813.
- Rauscher, F. H., G. L. Shaw, L. J. Levine, K. N. Ky, and E. L. Wright. (1993). Music and Spatial Task Performance. *Nature* 365: 611.
- Sarrafzadeh, A., Alexander, A., Dadgostar, F., Fan, C., & Bigdeli, A. (2008). How do you know that I don't understand? A look at the future of intelligent tutoring systems. . *Computers in Human Behavior*, 24 (4), 1342-1363.
- Scovel, T. (1978). The effect of affect on foreign language learning: A review of the anxiety research. *Language Learning*, 28(1), 129-142.
- VanLehn, K. (2006). The behavior of tutoring systems. *International Journal of Artificial Intelligence in Education*, 16 (3), 227-265.

Learner Attitude and Satisfaction in Chinese Vocabulary Learning under CALL

Hong-Fa HO^{a*} & Jing-Jenq WU^b

^a*Department of Applied Electronics Technology, National Taiwan Normal University, Taiwan, R.O.C.*

^b*International College of Chinese Studies, East China Normal University, China*

*jackho@ntnu.edu.tw

Abstract: In this information age, we try to understand the attitude of native English learners when they adopt technology in Chinese language learning. This paper uses qualitative analysis to investigate the attitude of Chinese language learners before and after the use of computer-assisted language learning (CALL) software in Chinese vocabulary learning. Participants were divided into three groups: one control group (1B, $N_1=6$) and two experimental groups (1A, $N_2=5$ and 2A, $N_3=13$). Questionnaires were handed out to participants before and after the experiment CALL course. This paper discusses the relationship of learning motivation and learning efficiency, vocabulary growth of learners using CALL, and participant satisfaction of using CALL as a supplement to traditional classroom teaching. The main findings are: the average satisfaction for Experimental Group 1A was 4.58 whereas the average satisfaction for Experimental Group 2A was 3.22 (full score 5); The average satisfaction for the experimental groups together (1A + 2A) was 3.60 (full score 5); the top three satisfaction categories are: The 1,033 Chinese vocabularies are appropriate for my present Chinese learning (4.06) > I can recognize and understand more Chinese characters and words (3.89) > I am getting familiar with the four tones of Hanyu (3.89); the bottom three satisfaction categories are: I am satisfied with the effectiveness of the CALL software (3.28) < I am satisfied with the art design of the interface (3.33) < I can understand and memorize more Chinese vocabularies from the simple English/Chinese translations; I think this method is fast and effective (3.39).

Keywords: CALL, Attitude, Satisfaction, Chinese words

3. Introduction

When learning a new language, the amount of vocabulary learners master influences their language level in listening, speaking, reading, and writing considerably. Each Chinese character has its own traits and is not easily learned by native English speakers. The great difficulty in learning Chinese characters and phrases makes it harder for learners to achieve a higher level in Chinese proficiency.

Computer-assisted language learning (CALL) has become a popular method for learning foreign languages. Goodfellow and Laurillard (1994) proposed four reasons to use CALL in language learning: 1) computers could record the learning process accurately, 2) the information typed could describe the strategies of the user, 3) the environment of CALL could be used as a “cognitive platform” for research, and 4) CALL was a “detailed evaluation tool” for inspecting language learning theories. Apart from the above reasons, the authors would like to add another eight points for using CALL in language learning, which are: 1) it is an efficient standardization tool in learning and testing contents, 2) the rapid switch between screenshots of CALL is more efficient than in classroom teaching, 3) a common interface for learning and testing reduces teaching management load, 4) adaptive scientific tests produce a more accurate test score, 5) a non-threatening learning environment makes making mistakes less intimidating, 6) learning is unrestricted by place, 7) learning is unrestricted by time, and 8) CALL may be integrated into classroom education to produce a more satisfactory teaching result.

Ho and Huong (2011) adopted the concept of Key Performance Indicator (KPI) of management science in EFL vocabulary learning, named Vocabulary Quotient (VQ). Three models of VQ were designed to test English spelling, word recognition, and listening proficiency. Chinese vocabulary recognition, listening, and word choice models were designed according to the concept of VQ in our experiment.

Methods including Dynamic Timing of Reviews (DTR), multi-sensory learning, simple English/Chinese translations, and native language learning were adopted by CALL in this experiment.

The theory of DTR was based on the Ebbinghaus Forgetting Curve (Ebbinghaus, 1913) and used the concept of arithmetic progression to explain human memory. According to the learning theory, the more sensors used in learning, the better the memory results. Reading, listening, touching (typing), speaking, and memorizing were practiced in CALL application. Chen (1999) claimed that “although direct Chinese/native language translations are often criticized, this method of learning Chinese is simpler, and its drawback may be offset by practical application in a Chinese language environment”. Chomsky (1959) advocated that language was learned by understanding the syntax of the target language and by imitation.

Although CALL has several advantages, what are the attitude of native English speaking learners in using CALL to learn difficult Chinese characters and phrases? What are their impressions of CALL? Future research and development may be benefited by understanding the attitude and satisfaction of participants after using CALL.

3.1 Research questions

According to the motivation of this study, research questions are listed below.

Q₁: What are the attitudes of native English speaking learners in learning Chinese characters with CALL?

Q₂: How learners are satisfied with learning Chinese with CALL?

4. Methods

For exploring the research questions, following subsections describe our experiment. A CALL Chinese vocabulary learning and reviewing system was developed by authors and used for this study.

4.1 Questionnaires

There are two questionnaires used in this study.

- 1) Questionnaire 1 (Pre-test Questionnaire): Investigates the Chinese learning motivation, Chinese vocabulary learning style, and Chinese learning cognitive mode of the participants.
- 2) Questionnaire 2 (Post-test Questionnaire): Investigates CALL software satisfaction, merit and fault evaluation, and improvement suggestion of the participants.

4.2 Participants

The participants of this experiment were all US language students studying Chinese in China. They had intermediate level in Chinese. These college students, range from 19 to 22 years old, came from two different education institutions and were divided into three groups. Experimental Group (1A, $N_2=5$) and Control Group (1B, $N_1=6$) come from a class (low-intermediate level) in CIEE (Council of International Education Exchange) Shanghai Center. The class was divided into two groups (1A and 1B), both groups received classroom education, but only 1A received an extra CALL course after class. Experimental Group 2 (2A, $N_3=13$) was a class (Class 1) from Carleton College, US. The students had an intermediate Chinese level. Class 1 all participated in the CALL experiment.

The ideal number of participants for this experiment was 30 people, but because of limited English native speakers, we could only find the class with the highest number of English native speakers to participate in the experiment.

4.2.1 Materials

This experiment adopted a Lexical CALL-DTR software system named “Chinese Words Booster-Grasp 1,000 Chinese Words in 20 hours.” This Chinese vocabulary CALL software included 1033 high frequently used vocabularies and used various learning methods such as DTR (Dynamic

Timing of Review) review method, e-flashcards, collaborative learning method, and simple translations to boost the vocabulary of Chinese language learners.

4.2.2 Apparatus

Two software systems were used in this experiment: the Chinese vocabulary testing system and the Lexical CALL-DTR Chinese vocabulary learning and reviewing system. Figure 1 shows the main screen of the system. Figure 2 shows the screen of practice function.

This CALL system had six question types (see Figure 3) specifically designed for word recognition and listening. Test 1 and Test 2 were Chinese reading tests: in Test 1 (see Figure 4), the learner read a Chinese word and chose its English meaning; in Test 2 (see Figure 5), the learner read an English narrative and chose its Chinese meaning. Screens of Test 3-6 are shown in Figure 6-9. Note that Test 3 and Test 4 provide Chinese speech sound to test ability of listening.



Figure 1. Main Screen of CALL-DTR system.

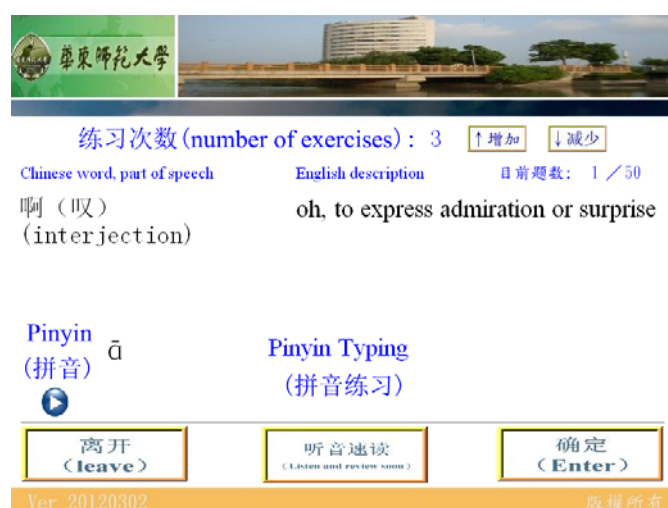


Figure 2. Screen of Practice Function.



Figure 3. There are six question types.



Figure 4. Screen of Test 1.



Figure 5. Screen of Test 2.



Figure 6. Screen of Test 3.



Figure 7. Screen of Test 4.



Figure 8. Screen of Test 5.

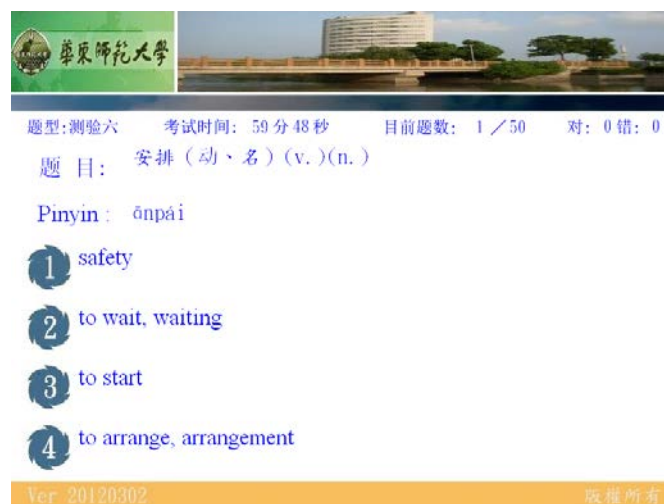


Figure 9. Screen of Test 6.

4.2.3 Procedure

The experimental groups adopted the Lexical CALL-DTR model. Their CALL learning records were collected and saved automatically. The control group did not have any after class courses. The operating hours of the experimental groups were 11 hours. Experimental Group 1 (1A) divided the course into 12 lessons, and Experimental Group 2 (2A) divided the course into 8 lessons.

The experiment procedure was as follows:

- a) Pilot study
- b) Pre-test questionnaire (Questionnaire 1)
- c) Pre-test of Chinese vocabulary proficiency
- d) CALL experiment
- e) Post-test of Chinese vocabulary proficiency
- f) Post-test questionnaire (Questionnaire 2)

5. Results and Discussion

5.1 The effect of learning elements on learning efficiency under CALL mode

In this section, we discuss the learning effect of CALL mode under three variables: the Hanyu learning motive variable, learning style of Chinese character and phrase variable, and the cognitive mode of Chinese character and phrase variable.

In Questionnaire 1 (Table 1), participants were offered six multiple-choice Hanyu learning motivation options in which all six options could be selected. The experimental group 1A and 2A (18 participants) together chose 50 options, and had an average of 2.8 choices each. The questionnaire result was analyzed according to 1) the percentage of each chosen option, 2) the order of the percentage of each chosen option, and 3) the order and analysis of progress in each option.

Table 1: Motives for learning Chinese.

No.	Learning motive option(s)	Option for motive in learning Chinese (with no.)	No. of times selected	Percentage of times selected	Mean percentage of progress
1A-1	1,2,3,4	1. Present or future business purposes.	3	6.0%	37.2%
1A-2	3				
1A-3	1,4				
1A-4	3,4,6	2. To make it easier for job hunting.	6	12.0%	16.5%
1A-5	3,4				
2A-1	3,4				
2A-2	3,4,6	3. Academic purposes	14	28.0%	20.8%
2A-4	3,4,6				
2A-5	4				
2A-6	2,3,4	4. Culture and trip purposes	16	32.0%	22.2%
2A-7	3,4				
2A-8	1,2,3,4,6				
2A-9	4,5,6	5. My ancestor(s) is Chinese; I think it's good for me to study Chinese.	3	6.0%	18.4%
2A-10	2,3,4				
2A-11	2,3,4				
2A-12	3,6	6. Interested in China or Chinese, but uncertain whether I will use Chinese in the future.	8	16.0%	19.5%
2A-13	2,4,5,6				
2A-14	3,4,5,6				

Table 2 shows the top three motives for learning Chinese are 1) culture and trip purposes, 2) academic purposes, and 3) interested in China or Chinese, but uncertain whether I will use Chinese in the future.

Table 2: Ranking of learning motives.

Ranking of choice	Learning motivation options	No. of times selected	Percentage of times selected	Mean percentage of progress
1	4. Culture and trip purposes	16	32.0%	22.2%
2	3. Academic purposes	14	28.0%	20.8%
3	6. Interested in China or Chinese, but uncertain whether I will use Chinese in the future.	8	16.0%	19.5%
4	2. To make it easier for job hunting.	6	12.0%	16.5%
5	1. Present or future business purposes.	3	6%	37.2%
5	5. My ancestor(s) is Chinese; I think it's good for me to study Chinese.	3	6%	18.4%
Total		50	100.0%	

5.2 Self-evaluation of participants in Chinese vocabulary growth

In this section, we discuss the participant satisfaction of CALL system and teaching aspects under CALL mode by analyzing the post-test (Questionnaire2) results of 18 experimental group participants (1A + 2A) in 1) self-evaluation of Chinese vocabulary growth, 2) self-satisfaction, 3) relationship between self-satisfaction and progress, and 4) relationship between self-satisfaction and post-test score.

In Question 1 of Questionnaire 2, participants were asked whether their Chinese vocabulary grew after using the software. From the results in Table 3, a third (38.9%) of the participants achieved high learning efficiency, half (55.6%) of the participants achieved a medium level learning efficiency, and 5.5% of the participants did not consider the software helpful in learning Chinese vocabulary. The participants had lower vocabulary retention than we predicted, especially 2A in “self-evaluation of

Chinese vocabulary growth.” We suspect this to be the result of insufficient number of courses (8 80-minute courses), but the lack of detailed introduction to CALL might have some relation to this result as well.

Table 3: Percentage of Chinese vocabulary growth in the self-evaluation of the experimental groups.

Options	No. of times selected	Percentage of times selected
(1) Chinese vocabulary increase sharply every week.	7	38.9%
(2) Chinese vocabulary increase slowly every week.	10	55.6%
(3) Chinese vocabulary did not increase.	1	5.5%
Total	18	100.0%

5.3 Participant satisfaction in CALL

The 18 participants in experimental groups 1A + 2A were analyzed in CALL satisfaction. With the full score as 5, the average satisfaction for 1A was 4.58 whereas the average satisfaction for 2A was 3.22 (Table 4). The reasons for the difference are as follows:

1) Although both groups had 11 hours of CALL course, the lessons for each group were divided into 12 lessons for 1A and 8 lessons for 2A. In comparison with 2A, 1A practiced more frequently and had more time to absorb the teaching material. The total amount of vocabulary of 2A was 1.5 times the amount of 1A, yet the total reviewed vocabulary was only 60.2% of 1A. Under this condition, 2A had lower learning efficiency and satisfaction than 1A.

2) Experimental group 1A and Control group 1B came from the same institution (CIEE), therefore, unlike 2A, 1A voluntarily participated in the experiment actively. Furthermore, the Chinese vocabulary level of 1A was lower than 2A, so the sense of achievement and satisfaction 1A got from completing the course exceeded that of 2A.

Table 4: Participant satisfaction in CALL.

Question Descriptions	1A	2A	Average of experimental groups
1. I am satisfied with the effectiveness of CALL.	4.20	2.92	3.28
2. CALL program helps increase my vocabulary.	4.80	3.23	3.67
3. I can recognize and understand more Chinese characters and words.	4.80	3.54	3.89
4. I am getting familiar with the four tones of Hanyu.	4.60	3.62	3.89
5. I can understand and memorize more Chinese vocabularies from the simple English/Chinese translation, which I think is fast and effective.	5.00	2.77	3.39
6. I am satisfied with the art design of the interface.	4.40	2.92	3.33
7. I am satisfied with the sound of the software.	3.80	3.46	3.56
8. The 1,033 Chinese vocabularies are appropriate for my present Chinese learning.	5.00	3.69	4.06
9. The ‘intensive review’ in the software really helps me in memorizing Chinese vocabulary.	4.80	3.00	3.50
10. The test function in the software really helps me memorize Chinese vocabulary.	4.40	3.08	3.44
Average	4.58	3.22	3.60

5.4 Participant satisfaction for the experimental groups as a whole

The average satisfaction for the experimental groups (1A + 2A) was 3.60 (Full score 5). This unsatisfactory result motivates us to improve the “Chinese vocabulary learning system CALL.”

The top three satisfaction categories are shown in Table 5, which means 1) the 1,033 word Chinese vocabulary are suitable for intermediate level students, 2) participants are generally satisfied with their vocabulary progresses, and 3) participants generally find their four tones of Hanyu has improved.

Table 5: Top three satisfaction categories in user experience of CALL.

Top three satisfaction categories	Question Descriptions	Average
1	H. The 1,033 Chinese vocabularies are appropriate for my present Chinese learning.	4.06
2	C. I can recognize and understand more Chinese characters and words.	3.89
3	D. I am getting familiar with the four tones of Hanyu.	3.89

Table 6 shows the bottom three satisfaction categories, which implies 1) a need to improve CALL system, 2) a need to design a better visual interface, and 3) the use of simple English/Chinese translations have opposite effects for 1A and 2A (1A gave full score and 2A gave 2.7). This may be due to the lack of sufficient introduction during the experiment; therefore, participants could not grasp the main idea of the exercise.

Table 6: Bottom three satisfaction categories in user experience of CALL.

Bottom three satisfaction categories	Question Descriptions	Average
1	A. I am satisfied with the effectiveness of the CALL software.	3.28
2	F. I am satisfied with the art design of the interface.	3.33
3	E. I can understand and memorize more Chinese vocabularies from the simple English translations. I think this method is fast and effective.	3.39

6. Conclusion

Based on the results of this study, some findings are concluded below. They might be useful for people who want to develop Chinese CALL systems for native English speakers.

6.1 The effect of learning motive on learning efficiency

The top three motives for learning Chinese were 1) culture and trip purposes, 2) academic purposes, and 3) interested in China or Chinese, but uncertain whether I will use Chinese in the future.

6.2 Self-evaluation of participants in Chinese vocabulary growth

A third (38.9%) of the participants achieved high learning efficiency, half (55.6%) of the participants achieved a medium level learning efficiency, and 5.5% of the participants did not consider the software helpful in learning Chinese vocabulary.

6.3 Participant satisfaction in CALL

With the full score as 5, the average satisfaction for Experimental Group 1A was 4.58 whereas the average satisfaction for Experimental Group 2A was 3.22.

6.4 Participant satisfaction for the experimental groups as a whole

The average satisfaction for the experimental groups (1A + 2A) was 3.60 (Full score 5). The top three satisfaction categories were: The 1,033 Chinese vocabularies are appropriate for my present Chinese learning (4.06) > I can recognize and understand more Chinese characters and words (3.89) > I am getting familiar with the four tones of Hanyu (3.89).

The bottom three satisfaction categories were: I am satisfied with the effectiveness of the CALL software (3.28) < I am satisfied with the art design of the interface (3.33) < I can understand and memorize more Chinese vocabularies from the simple English translations. I think this method is fast and effective (3.39).

6.5 Suggestion for vocabulary teaching

In the information age, self-access language learning is a suitable method for learners to study by themselves. Computer-assisted language learning software is a valuable tool for autonomous language learning. We suggest utilizing autonomous language learning, CALL theory, and empirical evidence to establish an effective Chinese vocabulary course and learning system. Furthermore, by integrating CALL in classroom teaching, teachers may efficiently control the education materials and design more comprehensive teaching plans.

6.6 Future development

Future development of the CALL software system may include integration with mobile interfaces, such as iOS and Android, as well as other online versions of CALL.

Acknowledgements

This work was partially supported by the “Aim for the Top University Project” (102J1A28) from National Taiwan Normal University and the Ministry of Education, Taiwan, R.O.C. In addition, we would like to thank Professor Zhang Jianmin of East China Normal University for his support in our experiment.

References

- Chen, X.-C. (1999). “Intermediate level Chinese as a foreign language teaching reform—Intensive vocabulary teaching. *Chinese Teaching in the World*, 4: 9-10.
- Chomsky, N. (1959). "A Review of B. F. Skinner's Verbal Behavior". *Language*, 35: 26–58.
- Ebbinghaus, H. (1913). *Memory: A contribution to experimental psychology* (No. 3). Teachers college: Columbia university.
- Goodfellow, R. & Laurillard, D. (1994). Modeling Learning processes in Lexical CALL, *CALICO Journal*, 11 (3).
- Ho, H.-F. & Huong, C. (2011). A multiple aspects quantitative indicator for ability of English vocabulary: vocabulary quotient. *Journal of Educational Technology Development and Exchange*, 4(1), 15-26.

The effect of Learning Community for Game-Based English Learning

Chih-Hung LAI^a, Wu-Jiun PENG^a, Wei-Hsuan CHEN^{a*}, Rong-Mu LIN^b

^aNational Dong Hwa University, Taiwan

^bLanguage Center, National Dong Hwa University, Taiwan

*teddy343434@gmail.com

Abstract: In recent years, English Vocabulary plays such an important role in the learning arena. However, most students felt boring when they were reciting English words which lead to lower learning motivation or higher dropout rate. Hence, many presently researches emphasized on Game-Based Learning approach, combining video games to learning that makes the learning process more interesting. Therefore, this research is aimed to discuss whether the Learning Community could enhance students' learning achievement in Game-Based Learning and to probe into different Gaming Methods, Self-Efficacy, as well as the Community Roles influenced learning achievement and learning activities among students. The participants in this research are both senior high and elementary students, divided into two groups for a two month experiment. The result indicated significant difference between the senior high and the elementary students' learning methods for learning activities. In addition, the Self-Efficacy demonstrates conspicuous dissimilarity to learning achievement. Furthermore, diverse community roles reveal significant difference to learning activities as well.

Keywords: Web-Based Learning Community, Community Roles, Game-Based Learning, Self-Efficacy, English Vocabulary

Introduction

Language is the most fundamental tool for communication and as we know, English plays such an important role no matter around the global or even in the domestic. Most of the country considered English not only a language but an academic subject. When it comes to Learning, English Vocabulary plays such an important role. Some research indicated that vocabulary is the cornerstone for language learning (Sun, Huang, & Liu, 2011). Wilkins (1972), pointed out that "Without grammar very little can be conveyed, without vocabulary nothing can be conveyed". This means enough vocabularies are needed for effectively communicate or express our own thoughts (Huang, Huang, Huang, & Lin, 2012). However, with the ineffective or less effective vocabulary learning strategies, most students feel boring which lead lower learning motivation or higher dropout rate (Huang et al., 2012). In order to enhance students learning motivation, Game-Based Learning approaches were applied, combining video games to learning which increases students' learning effect (Admiraal, Huizenga, Akkerman, & Dam, 2011; Coller & Scott, 2009; Ebner & Holzinger, 2007; Papastergiou, 2009; Robertson & Howells, 2008). Besides, most of the Game-based Learning methods relied on individual learning (Connolly, Stansfield, & Hainey, 2011; Liu & Chu, 2010), less interactions were performed between learners. Students could not understand each other's learning condition, not to mention to bring out interchange ideas to one another.

Hence, this research made good use of the Game-Based Learning on Social Network Service (SNS), enhancing the interaction between students to observe the incensement of learning motivation, learning activities and effectiveness. Although there are many recent studies concerned about Social Network Service (Chang & Lee, 2013; Lin, Hou, Wang, & Chang, 2013), very fewer of them compared the difference between Game-based Learning and Game-based Community, especially on disparity role play affected learning inside the community. Therefore, this research took the advantages of both GBL and SNS to provide students a flexible learning environment by influencing their learning effectiveness.

For the following reasons, the proposed study aimed to discuss whether the learning community was able to promote students' learning effect by using the characteristics that Social Network Service possessed, integrating the English Game-Based Learning system with Social Network to create the learning community. This combination was provided with the abilities to contrast the difference between Game-based Learning and Game-based Community in the meantime to probe into the distinct Gaming Methods, Self-Efficacy, and the Community Roles influenced learning achievement and learning activities among students. Moreover, the proposed research also took different educational background and the age condition into consideration, so that the learning effect toward elementary and senior high learners could be observed as well.

1. Related research about GBL Community on English Vocabulary Learning

1.1 Game-Based Learning

Recent researches indicated that Game-Based Learning could promote learning motivation (Coller & Scott, 2009; Ebner & Holzinger, 2007; Jong et al., 2013; Liu & Chu, 2010; Papastergiou, 2009; Sung & Hwang, 2012; Vos et al., 2011) as well as effectively enhancing learning efficiency (Coller & Scott, 2009; Ebner & Holzinger, 2007; Jong et al., 2013; Liu & Chu, 2010; Sung & Hwang, 2012). When it comes to learning attitude, the studies of both Connolly et al. (2012) and Sung, Hwang (2012) demonstrated positively effect. In addition, many of the learners believed they were willing to spend more time toward learning through GBL scenario (Coller & Scott, 2009; Connolly et al., 2011). Moreover, Sung and Hwang (2013) also implied that GBL was capable of enhancing self-Efficacy. With the comparison of traditional teaching methods, Game-Based Learning also revealed higher learning satisfaction (Liu & Chu, 2010).

1.2 Web-Based Learning Community

Ke and Hoadley (2009) considered that Web-Based Learning (WBL) Community held the power of not only emotional support, but a frontier of virtual learning. As we know, the characteristics of Social Network Service accomplished the existence of Web-Based Learning Community through interaction, communication and providing assistance as well as self-examinations. Those properties stimulate strongly to learning activity (Dabbagh & Kitsantas, 2012). Lin, Hou, Wang and Chang (2013) also indicated that Web-Based Learning Community created an environment for human interaction and information exchange and with the actual knowledge sharing as well as the experience interchange, both learning targets and learning effectiveness could be guaranteed (Chang & Lee, 2013; Holmes, 2013; Smithson et al., 2012; Sockett & Toffolia, 2012). What's more, some studies showed that with the combination of classes and Web-Based Learning Community, learning motivation might also arise (Cai & Zhu, 2012; Lin et al., 2013).

1.3 Community Roles

The community roles represented that in order to achieve learning targets, members

tried to understand or express expectation to each other through interaction in the Web-Based Learning Community, realize the function of each and every one of them (Lin et al., 2008). Lin et al. (2008) also mentioned that those members place a great importance on emotional exchange towards different learners, so that might able to comprehend and create new knowledge via information or experience sharing. Different roles were notified as initiators, orienteers, encouragers, recorders, gatekeepers, information/opinion seekers or givers, coordinators, and clowns in (Lin, Lin, & Huang, 2008). Other than that, Yeh (2010), classified the community roles in to eight categories, including, supervisors, information providers, atmosphere constructor, group instructors, opinion providers, reminders, troublemakers, and problem solvers.

1.4 Self-Efficacy

Self-efficacy implicated the persuasion, determination, and judgment toward human when facing obstacles or accomplishing tasks, indicating certain kinds of self-manifestation of organizing and execution abilities (Bandura, 1986). Chang (2012) emphasized on target setting reflected on students' Self-efficacy and achievement, demonstrating effectively enhancement on learning motivation, accomplishment, and Self-efficacy for actual targets subjected senior high learners. Moreover, most previous researches proven that knowledge sharing and Self-efficacy obtained positive capability to anticipate.

This research adopt the Motivated Strategies for Learning Questionnaire (MSLQ), made by Pintrich et al. (1989), hoping to achieve the Self-efficacy in the expectancy component section.

2. Research Methods

2.1 Experimental design and hypotheses

This experiment applied the nonequivalent pretest-posttest designs, the experimental design models are as Table 1.

Table 1 Experimental Design Models

Groups	Pretest	Experiment	Posttest
Experimental	O ₁	X ₁	O ₂
Control	O ₃	X ₂	O ₄

O₁ : The pretest of GBL community group, including English Self-efficacy test and achievement evaluation.

O₂ : The posttest of GBL community group, including System Satisfaction and achievement evaluation.

O₃ : The pretest of GBL group, including English Self-efficacy test and achievement evaluation.

O₄ : The posttest of GBL group, including System Satisfaction and achievement evaluation.

X₁ : The experiment of GBL community group, GBL system and WBL are applied

X₂ : The experiment of GBL group, the proposed GBL system is applied

Accordance with the purpose of this research, the hypotheses are as follows,

Hypotheses 1: The students of different learning styles reveal apparently difference on learning effect.

Hypotheses 2: The students of different learning styles reveal apparently difference on learning activity.

Hypotheses 3: English Self-efficacy reveals apparently difference on learning effect.

Hypotheses 4: English Self-efficacy reveals apparently difference on learning activity.
Hypotheses 5: Different community roles reveal apparently difference on learning effect.
Hypotheses 6: Different community roles reveal apparently difference on learning activity.

2.2 Subjects

The experiment is subjected to both junior high and elementary students, including 70 senior students from two classes of National Hualien Commercial High School and 95 elementary ones selected in four different classes. All of them were in Heterogeneous Grouping scenarios. This research divided the students into two groups, the Web-Based Learning Community group and the Game-Based Learning group.

2.3 Experimental procedure

This experiment took place from March to May, 2013 in an eight-week period. The pretest questionnaires were performed for both experimental and control groups, containing learning styles, English self-efficacy tests, and achievement evaluation. The experiment depended on different learning styles individually, that is, the experimental group made use of GBL community after classes and the control groups used GBL only. After the experiment was over, two groups executed posttest questionnaires, respectively. Eventually, the SPSS software was applied for statistical analysis.

2.4 Research tools

2.4.1 System development

The proposed English Vocabulary Game-Base Learning system mainly developed through Html5 Canvas and JavaScript. The system accomplished the ideal of learning everywhere with the assistance of MySQL dataset as back-end operation. It's capable of adopt any kinds of platform including personal computers, tablet computers, and mobile phones...etc. The system configuration is shown in the Figure.1 below.

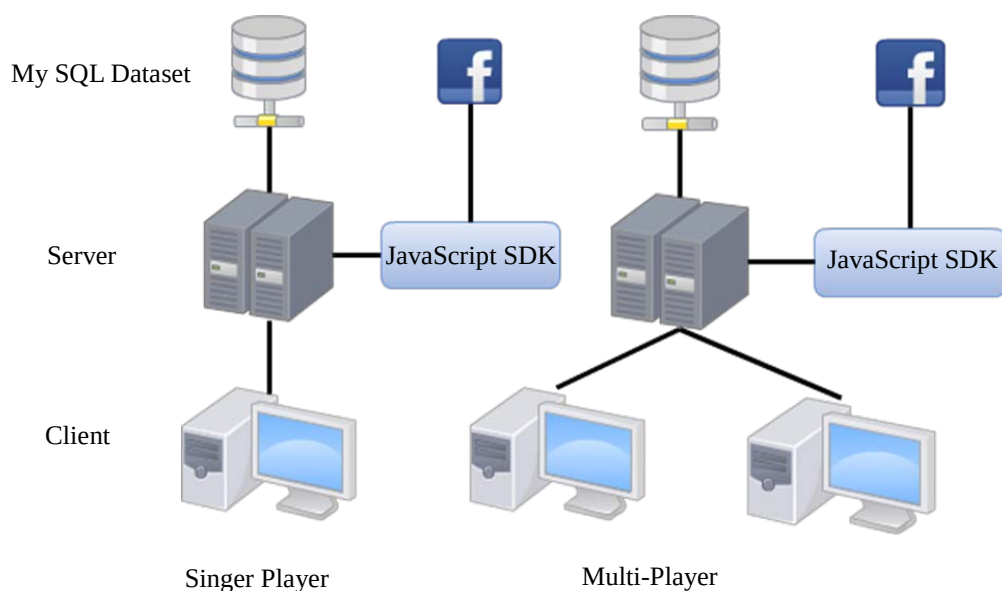


Figure 1: System Architecture Diagram

2.4.2 Analysis tool and the results of analysis

There are two questionnaires used in this study. The English Self-efficacy questionnaire came from the expectancy component of MSLQ to achieve the Self-efficacy. The community roles measurement relied on the amount of these movements known as “status update”, “Like”, and “reply” for group division. This research also classified those users as information providers, group instructors, and browsers, depending on ten times of each movement performed. The members carried out “status update” for more than ten times is called the information providers. The group instructors executed “Like”, or “reply” in total above ten times, and the browsers only observe with about action in the community. After the experiment came to an end, we use SPSS 14.0 (Windows) as statistical software for Quantitative Analysis. The hypotheses 1 & 5 used ANCOVA, the hypotheses 2 with t-test, and the hypotheses 3 & 4 employed in simple regression analysis. Eventually, the hypotheses 6, the ANOVA was held for further analysis.

3. Results and Discussion

3.1 Learning Achievement

The questionnaires of this research were given both before and after the experiments performed. All 70 questionnaires were filled out and valid for senior high students. There is one invalid questionnaire among 96 questionnaires subjected to elementary students. In order to realize different learning effect on Game-Base Learning and Game-Base Learning Community, ANCOVA was held for analysis.

Table 3-1 presented the Learning Achievement for seniors using ANCOVA, indicating no significance difference occur ($F(1, 67) = 3.64, p > .05$). Table 3-2 presented the Learning Achievement for elementary students using ANCOVA, revealing no significance difference as well ($F(1, 92) = 3.32, p > .05$).

Table 3-1 The Learning Achievement for seniors using ANCOVA

Source	SS	df	MS	F	p
Covariance (Pretest)	1130.2	1	1130.2	85.42	
Between Groups	48.18	1	48.18	3.64	.061
Error	886.52	67	13.23		

Table 3-2 The Learning Achievement for elementary students using ANCOVA

Source	SS	df	MS	F	p
Covariance (Pretest)	1276.87	1	1276.87	46.65	
Between Groups	91.02	1	91.02	3.32	.071
Error	2517.99	92	27.37		

To synthesize the above results, both seniors and elementary students displayed no significant difference on Game-Base Learning Community as well as Game-Base Learning scenario. However, after two-tailed t-test, apparently Learning Effect improved for all methods. This outcome were similar to Chang & Lee (2013) concerned about college students made use of Web-Based Community for learning and Cai & Zhu (2012) related to study foreign language. The reasons are further discussed, believing that not only teachers' or systems' assistance were necessary, but self-efforts or hardworking were essential towards great learning efficiency.

3.2 Learning Activity

Independent-Sample t-test was held in this experiment. Table 3-3 indicated significant difference among different Learning Styles on Learning Activity for senior high students ($t=3.1, p<.05$). On the contrary, Table 3-4 revealed no significant difference among different Learning Styles on Learning Activity for elementary students ($t=-3.61, p<.05$).

Table 3-3 The T-test of different Learning Styles on Learning Activity for seniors

Groups	<i>M</i>	<i>SD</i>	<i>t</i>	<i>df</i>	<i>p(two-tailed)</i>
GBL Community	15.92	4.32	3.1	68	.03*
GBL	12.94	3.58			

* $p<.05$.

Table 3-4 The T-test of different Learning Styles on Learning Activity for elementary

Groups	<i>M</i>	<i>SD</i>	<i>t</i>	<i>df</i>	<i>p(two-tailed)</i>
GBL Community	17.21	4.71	-3.61	93	.000***
GBL	22.35	8.58			

*** $p<.001$.

For both high schools and elementary students, GBL & GBL Community revealed apparently difference on Learning Activity. Seniors could enhance their system using times through GBL Community. This result was identical with Lin et al. (2013) and Sockett & Toffolial (2012). However, the control group participated in more learning activities compared to the experimental group. The reasons might have something to do with fewer use of social network for younglings. In addition, one of classes in the control group had shown stranger ability to compete, which encouraged colleges to learn. "The ability to compete" may be a crucial factor for the correlation studies.

3.3 Community Roles

Table 3-5 demonstrated the Community Roles on Learning Effect using ANCOVA towards seniors, indicating no significance difference occur ($F(2, 35) = 1, p>.05$). Table 3-6 represented the Community Roles on Learning Effect towards elementary students using ANCOVA, also, no significance difference shown ($F(2, 43) = .05, p>.05$).

Table 3-5 Community Roles on Learning Effect using ANCOVA towards seniors

Source	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>p</i>
Covariance (Pretest)	493.52	1	493.53	54.97	
Between Groups	17.95	2	8.98	1	.378
Error	314.21	35	8.98		

Table 3-7 implicated the Community Roles on Learning Activity using one way ANOVA towards seniors, indicating significance difference occur ($F(2, 36) = 28.61, p<.05$). Table 3-8 represented the Community Roles on Learning Activity using one way ANOVA towards elementary students, no significance difference shown ($F(2, 43) = .05, p>.05$).

Table 3-6 Community Roles on Learning Activity using one way ANOVA towards seniors

		<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>p</i>	Sheffe's Compare
Learning	B.G	435.07	2	217.54	28.61	.000***	Info. > Browser

Activity	I.G	273.7	36	7.6	Info.> Atmosphere
	Total	708.77	38		

*** $p < .001$.

Table 3-7 Community Roles on Learning Effect using ANCOVA towards elementary

Source	SS	df	MS	F	p
Covariance (Pretest)	539.79	1	539.79	23.24	
Between Groups	2.49	2	1.25	.05	.948
Error	998.59	43	23.22		

Table 3-8 Community Roles on Learning Activity using one way ANOVA towards elementary students

		SS	df	MS	F	p	Sheffe's Compare
Learning	B.G	271.8	2	135.9	7.99	.001**	Info. > Browser
Activity	I.G	748.07	44	17			
	Total	1019.87	46				

** $p < .01$.

To induce the foregoing result, that is senior high learners and elementary students demonstrated no apparently difference to distinct Community Roles on Learning Effect. Moreover, seniors showed significant difference to disparity Community Roles on Learning Activity. According to Sheffe's post hoc test, the Information Providers (Info.) surpassed better than the Atmosphere constructors (Atmosphere) and the Browsers. When it comes to elementary students, apparently difference appeared to distinct Community Roles on Learning Effect. Accordance with Sheffe's post hoc test, the Information Providers (Info.) won over than the Browsers. The above results shown that no matter seniors or elementary students, the Information Providers (Info.) used the Web-Based Learning Community more frequently than the Browsers and the Atmosphere constructors (Atmosphere).

4. Conclusions and Recommendations

The experiment indicated that different learning methods revealed remarkable difference between the senior high and the elementary students' on learning activities, implicating that distinct learning activities may influence students from dissimilar ages which affect English learning eventually. On the contrary, although the learning achievement demonstrated conspicuous improvement, there are no apparently differences between the two kinds of students. However, when it comes to learning factors, distinct Learning Styles implicated no significant difference on learning achievement and learning activities. In addition, Self-efficacy demonstrates conspicuous dissimilarity towards learning achievement but not for learning activities. In the community roles part, the learning achievement of elementary and senior high students' shared no influence among different roles. The other way round, diverse community roles reveal significant difference to learning activities.

As a result of time and manpower constraints, the system function still exist several limitations. For the future, we hope to extend the experimental areas and process to long terms' trace and observation for the bigger picture of the interaction among Web-Based Learning Community as well as the Social Network Service to its maximum potential.

References

- Admiraal, W., Huizenga, J., Akkerman, S., & Dam, G. t. (2011). The concept of flow in collaborative game-based learning. *Computers in Human Behavior*, 27(3), 1185-1194.
- Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Prentice Hall, Englewood Cliffs, New York.
- Bin-Shyan, J., Chien-Hung, L., Yen-Teh, H., Tsong-Wuu, L., & Cheng-Yu, L. (2013). Using Game-Based Cooperative Learning to Improve Learning Motivation: A Study of Online Game Use in an Operating Systems Course. *Education, IEEE Transactions on*, 56(2), 183-190.
- Bock, G. W., & Kim, Y. G. (2002). Breaking the myths of rewards: an exploratory study of attitudes about knowledge sharing. *Information Resources Management Journal (IRMJ)*, 15(2), 14-21.
- Cai, S., & Zhu, W. (2012). The Impact of an Online Learning Community Project on University Chinese as a Foreign Language Students' Motivation. *Foreign Language Annals*, 45(3), 307-329.
- Chang, W.L., & Lee, C.Y. (2012). Trust as a learning facilitator that affects students' learning performance in the facebook community: An investigation in a business planning writing course. *Computers & Education*, 62, 320-327.
- Chen, M. L. (2009). Influence of grade level on perceptual learning style preferences and language learning strategies of Taiwanese English as a foreign language learners. *Learning and individual differences*, 19(2), 304-308.
- Coller, B. D., & Scott, M. J. (2009). Effectiveness of using a video game to teach a course in mechanical engineering. *Computers & Education*, 53(3), 900-912.
- Connolly, T. M., Stansfield, M., & Hailey, T. (2011). An alternate reality game for language learning: ARGuing for multilingual motivation. *Computers & Education*, 57(1), 1389-1415.
- Dabbagh, N., & Kitsantas, A. (2012). Personal Learning Environments, social media, and self-regulated learning: A natural formula for connecting formal and informal learning. *The Internet and Higher Education*, 15(1), 3-8.
- Ebner, M., & Holzinger, A. (2007). Successful implementation of user-centered game based learning in higher education: An example from civil engineering. *Computers & Education*, 49(3), 873-890.
- Holmes, B. (2013). School teachers' continuous professional development in an online learning community: lessons from a case study of an eTwinning Learning Event. *European Journal of Education*, 48(1), 97-112.
- Huang, Y.M., Huang, Y.M., Huang, S.H., & Lin, Y.T. (2012). A ubiquitous English vocabulary learning system: Evidence of active/passive attitudes vs. usefulness/ease-of-use. *Computers & Education*, 58(1), 273-282.
- Ke, F., & Hoadley, C. (2009). Evaluating online learning communities. *Educational Technology Research and Development*, 57(4), 487-510.
- Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development* (Vol. 1): Prentice-Hall Englewood Cliffs, NJ.
- Lin, F. R., Lin, S. C., & Huang, T. P. (2008). Knowledge sharing and creation in a teachers' professional virtual community. *Computers & Education*, 50(3), 742-756.
- Lin, P. C., Hou, H.T., Wang, S.M., & Chang, K. E. (2013). Analyzing knowledge dimensions and cognitive process of a project-based online discussion instructional activity using Facebook in an adult and continuing education course. *Computers & Education*, 60(1), 110-121.
- Liu, T. Y., & Chu, Y.L. (2010). Using ubiquitous games in an English listening and speaking course: Impact on learning outcomes and motivation. *Computers & Education*, 55(2), 630-643.
- Papastergiou, M. (2009). Digital Game-Based Learning in high school Computer Science education: Impact on educational effectiveness and student motivation. *Computers & Education*, 52(1), 1-12.
- Robertson, J., & Howells, C. (2008). Computer game design: Opportunities for successful learning. *Computers & Education*, 50(2), 559-578.
- Smithson, J., Jones, R. B., & Ashurst, E. (2012). Developing an online learning community for mental health professionals and service users: a discursive analysis. *BMC Medical Education*, 12(1), 12.
- Socket, G., & Toffoli, D. (2012). Beyond learner autonomy: A dynamic systems view of the informal learning of English in virtual online communities. *Procedia-Social and Behavioral Sciences*, 34, 212-215.
- Sun, K. T., Huang, Y.M., & Liu, M.C. (2011). A WordNet-based near-synonyms and similar-looking word learning system. *Educational Technology & Society*, 14(1), 121-134.
- Sung, H.Y., & Hwang, G.J. (2013). A Collaborative Game-based Learning Approach to Improving Students' Learning Performance in Science Courses. *Computers & Education*, 63, 43-51.
- Vos, N., van der Meijden, H., & Denessen, E. (2011). Effects of constructing versus playing an educational game on student motivation and deep learning strategy use. *Computers & Education*, 56(1), 127-137.
- Wilkins, D. A. (1972). *Linguistics in language teaching*. London: Edward Arnold.

Yeh, Y.-C. (2010). Analyzing online behaviors, roles, and learning communities via online discussions. *Educational Technology & Society*, 13(1), 140-151.

Effects of the Concept Mapping and Reflection Strategies on Motivations of EFL Learners

Ching-Kun HSU

Department of Technology Application and Human Resource Development, National Taiwan Normal University, Taiwan
ckhsu@ntnu.edu.tw

Abstract: This study evaluated the learning motivations of the foreign language oral interaction course integrating Computer-Mediated Communication and Native-Speaker peer-tutoring strategies based on the assessment results of ARCS motivation design. The study found that no matter the students used the reflection strategy or not after the class, they will have confidence in the oral peer-tutoring activities when the students do concept mapping activities every time before they conducted the oral peer-tutoring activity via CMC platform. However, if the students did not use the concept mapping strategy, the students could use the reflection strategy in the post-activity had higher confidence than the students who did not use the reflection strategy when they reviewed after the class. Conversely, the study found that no matter the students used concept mapping strategy or not before the class, they will have confidence in the oral peer-tutoring activities when the students do reflection activities every time they end the oral peer-tutoring. However, if the students did not use reflection strategy, the students using concept mapping strategy in pre-study had higher confidence than the students who did not use concept mapping strategy when they prepared before the class.

Keywords: Computer-Mediated Communication, English Native-Speaker, Peer-Tutoring, ARCS Motivation Design, learning motivation

1. Introduction

This study applied the peer-tutoring strategy which was defined as a part of the collaborative learning (Slavin, 1995). Some scholars noted that it is a one-by-one teaching and learning between students (Utley & Mortweet, 1997). The peer tutoring activities could be conducted based on different level of pairing, complementary relationship, or the combination across ages, and so on (Hughes & Fredrick, 2006). In the process of peer tutoring, the students who play as tutors can improve their learning from teaching other peers (Sharpley, Irvine, Sharpley, 1983). The student who is the tutee will learn from the urge of the peers. Both the tutor and tutee will become much active in participating in concept explaining because of social activity (Rohrbeck, Ginsburg-Block, Fantuzzo & Miller, 2003). The previous study also indicated that the students could gain active learning from the constructions and explanations of content, aware and corrections of errors, exploration of reactions or responses in peer-tutoring activities (Webb, 1989). Therefore, during peer tutoring, the students not only learn from being taught but also from questioning, retorting and challenging the peer's views (Webb, 1989; Sharpley, Irvine, Sharpley, 1983). As a result, the peer-tutoring strategy is a both win-win learning strategy between the students who play the role of a tutor or a tutee.

Take language learning for an example, a good use of peer tutoring brings tutors more chances to utilize language, and bring tutees higher learning motivations and communication opportunities. If the students are in different countries, they can conduct language peer-tutoring activities by the assistance of digital technologies, so as to across the limitations of geography and interact with native speakers. When the students become the tutors, they will learn by doing and teaching because of their task completion and practical interactions with foreigners;

conversely, when the students are the tutees, they will have more opportunities to get adaptations to the habitual practice or common usage of the foreign language from the native speakers. In light of the advantages of the peer-tutoring strategies in language learning, there was a primary school from Britain and the other one from Spain conducting peer-tutoring activities in learning writing of second language. The results showed that when student was performed as a tutor they got the sense of honor and learned from teaching. The students thought that native speaker corrected and taught them how to use the language more properly. Hence, students had improved their vocabularies and writing ability (Dekhinnet, Topping, Duran & Blanch, 2008). The students in Britain and Spain said that they loved learning second language through peer tutoring with native-speaker peers since they could feel pleasant to make foreign friends and had social motivations. Learning language requires practical opportunities to use. Language chatting or interactions has a real listener and peer response when the students had transnational learning activities with native-speaker peers. In traditionally oral class, teachers often let students do the speaking practice with their classmates (Flanigan, 1991). In other word, in traditional class, the students practice language speaking with their classmate instead of native speaker. Therefore, it is difficult for the students to combine international cultural background and native-speaker perspectives during the communication (Hickey, 2007). Nowadays, the Internet has broken up the geographic limitations, so that the students are not restricted to only do oral interactions with their classmates. The students can perform oral communication with native-speaker peers in abroad or different cultural backgrounds by using Computer Mediated Communication (CMC) technologies.

Applying technology to learn foreign languages or second language, and incorporating proper teaching strategies, such as the peer tutoring strategy, the concept mapping strategy, reflection strategy and so on will be helpful to build up feasible scaffoldings for the students and achieve comprehensive language as well as culture communications (Levy, 2009; Chapelle 2009). Therefore, this study conducted the foreign language exchange activities between Singaporean and Taiwanese students by means of peer tutoring strategy. The students could not only do oral practice but also had a chance to interact with the native-speakers' perspectives. The Ministry of Education in Taiwan highlighted that students should focus on listening and speaking during learning English. In this study, the students interact with their peers abroad by using the CMC technology. Among several CMC technologies, this study used Google-talk which is a freeware. This study mainly evaluated the motivations of the students when they have different treatments during the peer tutoring activities with their native-speaker peers.

Some studies have explored cross-national language learning. For example, a study used the asynchronous CMC technology between Taiwan and Japan to assist the students to practice oral communications of foreign language (Natalie Wu & Kawamura, 2012). In addition, there have been many countries using CMC technologies to conduct the transnational language learning activities, such as Taiwan and the United State, China and the United State, Taiwan and Australia. Some of them used synchronous CMC channels, while some of them used asynchronous CMC manners. Recently, some scholars suggested that the future researches ought to help students build up partnerships with English native speakers in order to have more oral exercise (Vivian Wu, Marek & Huang, 2012). They also noted that it is beneficial for English as Foreign Language (EFL) learners to provide the real-life situations or leaning topics with locality characteristics of the native speakers. However, the participants of most studies previous mentioned were mainly college students. Little research has investigated on the students in the primary or secondary schools by means of using a synchronous CMC technology, such as Google-talk in this study, for cross-national language learning. This study stands on an important state because of assisting the students in the secondary schools to learn foreign language by properly using CMC technologies in the well-design activities and learning process via different instruments, and bringing the students opportunities to make

contact with the native-speaker peers on the house. This study aimed at finding out whether the instructional design and different leaning strategies incorporated in the peer tutoring activities via the CMC platform (i.e. Google talk) impact on the motivations of the students. The following section will further review some related work.

2. Related Work

There were several researches that made a good use of computer mediated functioning (Spitzber, 2006). The possibility of learning second language with CMC tools has gradually attracted researchers' attentions. Some researches indicated that VC could make learners involve in the online real-time oral communications (Grace Peng, 2012). Furthermore, a previous study pointed out that Computer Medicated Communication Competence (CMCC) model included many aspects, such as the motivation, knowledge, skill, situation and achievement (Spitzberg, 2006). The competence of the students' attentions and expressions would be affected by the process, background, and the situation when the communication occurred. The competence then brings the motivations of the students and further results in the performance of the students. In brief, in CMCC model, the motivations of the students had impacts on their attitudes toward online interactions by means of CMC. Furthermore, another study indicated that communications with foreigners by means of CMC caused the motivations and interests of the students due to the different culture background and appearance of the native speakers' countries (Natalie Wu & Kawamura, 2012). Whether the foreign language oral course conducted between countries on the CMC way causes the attentions of the students, recalls the relevance to their daily lives, encourages the confidence in themselves, and brings the perceptions of satisfactions will have impacts on the learning motivations of the students. When the languages between the two countries are complementary to each other without time differences, it would be appropriate for the students in the two countries to conduct the cross-national language exchange activities. For example, the first problem of carrying out synchronously interactive activities at school between the United States and Taiwan is too large divergence between the time zones of the two locales. In other words, to coordinate with American time, students need to come to school at night to participate this language class. In addition, the second problem may be the lacks of complementary languages so the students cannot use substitute language to keep communicating when they do not understand what their partners said at all. As a result, the interactions will be interrupted because the students could not switch to other language to continue the dialogue when one student does not understand to another. The activity would be quitted due to the misunderstanding. This study tried to conduct the experiments and prevent such problems. Therefore, the students who are the native speakers of English are employed in this study from Singapore.

The ARCS motivation model was proposed based on four scales which are attention(i.e., A), relevance(i.e., R), Confidence (i.e., C) to maintain and improve the learning motivations of the students in an instructional activity. In short, the term ARCS is the abbreviation of A(Attention), R(Relevance), C(Confidence) and S(Satisfaction) (Keller, 1983). Research has indicated that one of the key points for successful online learning is to design the instructional activities based on the motivation model (Keller, 1999). The following paragraphs will explain the four steps of the ARCS motivation model one by one according to the factors defined by the advocate (Keller, 1987, 1999). In sum, the ARCS motivation model was constructed for assessing whether the instructional design will cause or reduce the motivations of the students based on the four scales which are Attention, Relevance, Confidence, Satisfaction (Keller, 1987, 1999). This motivation model is also able to be employed in the evaluation of the distance course design (Keller, 1993). Therefore, this study introduced the

ARCS measurement to assess the motivations of the students in the learning activities of the language peer-tutoring with their partners abroad via the CMC platform.

This study aimed at well using the existing digital technologies of Computer Mediated Communication, such as Google Hangouts, and integrating them with the peer tutoring strategy and a learning support approach, such as concept mapping, to achieve online language oral practices and interactions with native speakers without distance limitations. The learning support approach used for organizing the cognitions of the teenagers before the oral interactions in this study is concept mapping. A previous study combined the concept mapping method into the story-telling activities, and found that the students were like the tutors who needed to share, organize, evaluate, communicate, and turn out their daily experience or knowledge to their own voice and materials reacting and conveying the ideas they developed (Liu, Fan-Chiang, Choum & Chen, 2010). The students could have advanced comprehension and application of their present knowledge and experience from the process of telling (Druin, 1998). A previous study also indicated that concept mapping did contributions to organize the complicated structure, clarify the topics, and come out with much more creative ideas with richer contents during telling (Liu, Chen, Shih, Huang & Liu, 2011). In this study, the students did not use concept mapping to prepare tell story, but use it to draw up the main ideas they were going to say and arrange the vocabulary or sentences they were going to use before they conducted the peer-tutoring activities. In other words, this study brought the concept map for students to establish and organize their teaching concept graph which can help them organize and prepare the guidance for their peers, help them get higher level of thinking, cognitive construction, and learn from the process of preparation.

Concept map used to be applied in some science learning topics (Novak, Gowin & Johansen, 1983). Later, it was also widely used in different subjects, including support instruction, course development, assessment, and so on. A previous study used concept map for course planning tool, and showed that learners would like to use concept map for course planning in real teaching situation (Martin, 1994). Accordingly, in our study, concept map is utilized to support students to organize their ideas and content they will interact with their peers in foreign language during peer tutoring, so that they can easily get connections among teaching process, concepts, and oral contents in Synchronous Computer Mediated Communication tutorial process. Recently, more and more studies used concept maps in language learning and found that concept maps were beneficial to reading comprehensions of the students (Maps, Meaningful, Sánchez, Cañas & Novak, 2010; Liu, Chen & Chang, 2009). This study would use concept map to organize the materials the students prepared before oral peer-tutoring activities via computer mediated communication.

3. Method

1. 3.1. Participants and Treatment Procedures

There are four groups, totally 130 participants, joining the instructional experiments. They received different treatments in different group. The four groups came from four different schools in Taiwan. They all learn English as Foreign Language (EFL). Their learning course and content is the same. All the four groups conducted the same instructional themes. They used Computer-Mediated Communication (CMC) platform, such as Google talk/hangouts, to conduct English oral interactions with native speakers in abroad (i.e. Singapore). When the

students carry out each time of the peer tutoring activity, there are three different stages which they will confront.

Before the class, some students used concept mapping strategy which the teacher instructed to prepare their peer-tutoring materials, while some students did not used concept mapping strategy and only used their own notes to prepare their peer-tutoring material, which is the first stage of the task. In the oral class, the students actually conducted the synchronous peer-tutoring activity by using computer-mediated communication technology to interact with their native-speaker partners abroad. That is the second stage of the task. Finally, after the class, some students had to reflect what they taught and spoke with their native-speaker partners abroad in the oral class while some students did not have to do reflection activity in accordance with their own speaking and instructional content. The following table showed the number and treatments of the four groups. The group one named NC_R was not treated the concept mapping strategy for preparation before the peer-tutoring on CMC platform, but was treated the reflection activity after peer-tutoring. The group two called NC_NR was not treated concept mapping strategy before the peer-tutoring on CMC platform, and was not treated the reflection activity after peer-tutoring, either. The group three named C_NR was treated concept mapping strategy before the peer-tutoring on CMC platform, and was not treated the reflection activity after peer-tutoring. The group four named C_R was treated concept mapping strategy before the peer-tutoring on CMC platform, and was treated the reflection activity after peer-tutoring.

Table 1. Two-factor variances comprise four groups

Treatments	No Concept Map (NCM)	Concept Map (CM)
Reflection	Group 1 (NC_R), N=23	Group 4 (C_R), N=26
No Reflection	Group 2 (NC_NR), N=40	Group 3 (C_NR), N=41

3.2. Research tools

The research tool of the computer-mediated communication used in this study was Google Hangouts. The research tool of evaluation in this study utilized the ARCS motivation questionnaire for measuring the students' learning motivation based on the Course Interest Survey (CIS). The ARCS Questionnaire was developed by Keller (Keller & Subhiyah, 1993; Keller, 2006). It consists of four dimensions (i.e., Attention, Relevance, Confidence and Satisfaction). The questionnaire totally contains 34 items with a 5-point Likert rating scheme, including 8 items for "Attention", 9 items for "Relevance", 8 items for "Confidence", and 9 items for "Satisfaction". The totally perfect scores of the 34 items are 170 (Keller & Subhiyah, 1993; Keller, 2006). The threshold each item is 3.5 (Ley, 2010). When the score of every item is higher than the threshold (i.e., 3.5), the peer-tutoring activities successfully motivate the students to learn oral speaking. The Cronbach's alpha values of the four dimensions are 0.84, 0.84, 0.81, and 0.88, respectively. The overall coefficient of reliability is 0.95. In addition, this study increased two open questions in the questionnaire to investigate the difficulties or other opinions which the students met in each time of activity.

4. Results and Discussions

4.1. Whether using concept mapping strategy or not in pre-task significantly impacts on the

learning motivations of the students in the oral peer-tutoring?

The students who used concept mapping strategy in pre-task of preparation showed higher confidence during the oral peer-tutoring activities. Therefore, the cognition clearly organized by using mind tool did contribute to the motivations of the students, especially in the performance of confidence ($t=2.14^*$, $p<.05$) shown as Table 2 although there were no significant improvement in the motivation scale of Attention ($t=1.41$, $p>.05$), Relevance ($t=1.68$, $p>.05$), and Satisfaction ($t=1.19$, $p>.05$). The CM group refers to the students who used concept mapping strategy in the pre-task, and the NCM group means the students who did not use concept mapping strategy in the pre-task.

Table 2.Independent sample t-test between the CM group and NCM group

Scale	Group	N	Mean	SD	t
Confidence	CM	67	4.01	0.64	2.14*
	NCM	63	3.77	0.63	

* $p<.05$

4.2. Whether conducting reflection activity or not in post-task significantly impacts on the learning motivations of the students in the oral peer-tutoring?

The students who used reflection strategy in post-task after peer-tutoring activities on the network showed higher confidence so as to motivate their learning interests. Therefore, the reflection strategy is beneficial to increase the motivations of the students, especially in the performance of confidence ($t=2.24^*$, $p<.05$) shown as Table 3 although there were no significant improvement in the motivation scale of Attention ($t=0.86$, $p>.05$), Relevance ($t=1.62$, $p>.05$), and Satisfaction ($t=1.00$, $p>.05$). The Reflection group refers to the students who used the reflection activity in the post-task, and the No Reflection group means the students who did not use the reflection strategy in the post-task.

Table 3. Independent sample t-test between the Reflection and No Reflection group

Scale	group	N	Mean	SD	T
Confidence	Reflection	49	4.04	0.48	2.24*
	No Reflection	81	3.81	0.71	

* $p<.05$

2. 4.3. Cross Analysis between the two factors

There were 49 participants conducting reflection strategy in the post-task, shown in the previous section. Among the 49 students, they came from two different pre-tasks. Some students were belong to the CM group which used the concept mapping strategy in the pre-task (N=26) while the others were the NCM group which did not use the concept mapping strategy in the pre-task (N=23). Both of the groups used reflection strategy after class in each round of peer-tutoring activity. The results showed that there was no significant difference between the two groups in terms of the ARCS motivations, including the dimensions of attention ($t=-1.86$, $p>.05$), relevance ($t=-1.43$, $p>.05$), confidence ($t=-0.49$, $p>.05$), and satisfaction ($t=-1.24$, $p>.05$).

There were 81 participants who did not conduct reflection strategy in the post-task. Among the 81 students, they came from two different pre-tasks. Some students were belong to the CM group which used the concept mapping strategy in the pre-task (N=41) while the others

were the NCM group which did not use the concept mapping strategy in the pre-task (N=40). The groups did not use reflection strategy after class in each round of peer-tutoring activity. The results showed that there was significant difference between the two groups in terms of the confidence dimension ($t=-2.15^*$, $p<.05$, shown as Table 4) in the four scales of motivation while the other three dimensions, attention ($t=-0.71$, $p>.05$), relevance ($t=-1.08$, $p>.05$), satisfaction ($t=-0.65$, $p>.05$), did not show remarkable difference.

Table 4. The NCM and CM groups did NOT use the reflection strategy

Scale	group	N	Mean	SD	t
Confidence	NCM	40	3.64	0.65	-2.15*
	CM	41	3.97	0.74	

* $p<.05$

On the other hand, there were 67 participants using concept mapping strategy in their pre-task. Among the 67 students, they joined different post-tasks. Some students were belong to the Reflection group which used the reflection strategy in the post-task (N=26) while the others were the No Reflection group which did not use the reflection strategy in the post-task (N=41). The groups used the concept mapping strategy before class in each round of peer-tutoring activity. The results showed that there was no significant difference between the two groups in terms of the ARCS motivations, including the dimensions of attention ($t=0.93$, $p>.05$), relevance ($t=1.27$, $p>.05$), confidence ($t=0.71$, $p>.05$), and satisfaction ($t=0.80$, $p>.05$).

There were 63 participants who did not utilize the concept mapping strategy in the pre-task. Among the 63 students, they joined different post-tasks. Some students were belong to the Reflection group which used the reflection strategy in the post-task (N=23) while the others were the No Reflection group which did not use the reflection strategy in the post-task (N=40). The groups did not use the concept mapping strategy before class in each round of peer-tutoring activity. The results showed that there was significant difference between the two groups in terms of the confidence dimension ($t=-2.29^*$, $p<.05$, shown as Table 5) in the four scales of motivation while the other three dimensions, attention ($t=0.22$, $p>.05$), relevance ($t=0.96$, $p>.05$), satisfaction ($t=0.43$, $p>.05$), did not show remarkable difference.

Table 5. The Reflection and No-reflection groups did NOT use the concept mapping strategy

Scale	group	N	Mean	SD	t
Confidence	Reflection	23	4.01	0.55	2.29*
	No Reflection	40	3.64	0.65	

* $p<.05$

5. Conclusions

In the 4.1 section, the study has confirmed that the concept mapping strategy before class could increase the confidence of the students so as to result in the motivation of the oral speaking course integrating the peer-tutoring activity on CMC platform. No matter the students used the reflection strategy or not after the class, they will have confidence in the oral peer-tutoring activities when the students do concept mapping activities every time before they conducted the oral peer-tutoring activity via CMC platform. However, if the students did not used the concept mapping strategy, the students could use the reflection strategy in the post-activity had higher confidence than the students who did not used the reflection strategy

when they reviewed after the class ($t=2.29^*$, $p<.05$), which is shown as Table 5. This implied that the skeleton of the whole oral interaction theme which was reviewed by the reflection strategy provided good training for students.

In the 4.2 section, the study has confirmed that the reflection strategy after class could increase the confidence of the students so as to result in the motivation of the oral speaking course integrating the peer-tutoring activity on CMC platform. No matter the students used concept mapping strategy or not before the class, they will have confidence in the oral peer-tutoring activities when the students do reflection activities every time they end the oral peer-tutoring. However, if the students did not used reflection strategy, the students using concept mapping strategy in pre-study had higher confidence than the students who did not used concept mapping strategy when they prepared before the class ($t=-2.15^*$, $p<.05$). This implied that the skeleton of the whole oral interaction theme which was organized by the concept mapping strategy in advance provided good connection and logic in the integrity for students.

Consequently, this study found that the students had best at least to choose one of the two strategies which are the concept mapping strategy in the pre-task and the reflection strategy in the post-task. Regardless which strategy the students choose, their confidence will be improved when they choose one of the two strategies at least, so as to result in higher motivation of oral peer-tutoring via computer-mediated communication.

1. Acknowledgments

This study is supported in part by the National Science Council of the Republic of China under contract numbers NSC 102-2511-S-003-055-MY2.

2. Reference

- Chapelle, C. A. (2009). The relationship between second language acquisition theory computer-assisted language learning. *The Modern Language Journal*, 93(1), 741-753.
- Chang, K.-E., Sung, Y.-T., & Chen, S. (2001). Learning through computer-based concept mapping with scaffolding aid. *Journal of Computer Assisted Learning*, 17(1), 21-33.
- Dekhinet, R., Topping, K., Duran, D. & Blanch, S. (2008). Let me learn with my peers online!: Foreign language learning through reciprocal peer tutoring, *Innovate: Journal of Online Education*, 4 (3), 1-6.
- Druin, A. (1998). *The design of children's technology*. San Francisco, CA, USA: Morgan Kaufmann Publishers Inc.
- Flanigan, B. O. (1991). Peer tutoring and second language acquisition in the elementary school. *Applied Linguistics*, 12 (2), 142-158.
- Grace Peng, H.-F. (2012). *Facilitating Reading Comprehension by Using Forums and Videoconferences*. Paper presented at the 15th International CALL Research Conference, Taichung, Taiwan.
- Hickey, T. M. (2007). Children's language networks in minority language immersion: What goes in may not come out. *Language and Education*, 21 (1), 46-65.
- Hughes, T. A., & Fredrick, L. D. (2006). Teaching vocabulary with students with learning disabilities using classwide peer tutoring and constant time delay. *Journal of Behavioral Education*, 15(1), 1-23.
- Keller, J. M. (1983). *Motivational design of instruction*. In C. M. Reigeluth (Ed.), *Instructional-design theories and models: An overview of their current status*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Keller, J. M. (1984). *The use of the ARCS model of motivation in teacher training*. In K. Shaw & A. J. Trott (Eds.), *Aspects of Educational Technology Volume XVII: staff Development and Career Updating*. London: Kogan Page.
- Keller, J. M. (1987). Development and use of the ARCS model of motivational design. *Journal of Instructional Development*, 10(3), 2-10. John Keller's Official ARCS Model Website
- Keller, J. M., & Subhiyah, R. (1993). *Course interest survey*. Tallahassee, FL: Instructional Systems Program, Florida State University.
- Levy, M. (2009). Technologies in use for second language learning. *The Modern Language Journal*, 96(1),

769-782.

- Liu, P. L., Chen, C. J., & Chang, Y. J. (2009). Effects of a computer-assisted concept mapping learning strategy on EFL college students' English reading comprehension. *Computers & Education*, 54(2), 436-445.
- Liu, C.-C., Chen, H. S., Shih, J.-L., Huang, G.-T., & Liu, B.-J. (2011). An enhanced concept map approach to improving children's storytelling ability. *Computers & Education*, 56(3), 873-884.
- Liu, C. C., Fan-Chiang, S. H., Chou, C. Y., & Chen, Y. S. (2010). Knowledge exploration with concept association techniques. *Online Information Review*, 34(5), 786-805.
- Maps, C., Meaningful, M. L., Sánchez, J., Cañas, A., & Novak, J. (2010). Concept map: A strategy for enhancing reading comprehension in English as L2.
- Martin, D. J. (1994). Concept Mapping as an aid to lesson planning: A longitudinal study. *Journal of Elementary Science Education*, 6(2), 11-30.
- Natalie Wu, P.-H. & Kawamura, M. (2012). *Willingness to Communicate Online - Asian Students in a Cross-Cultural English Learning Project*. Paper presented at the 15th International CALL Research Conference, Taichung, Taiwan.
- Novak, J. D., & Cañas, A. J. (2006). The origins of the concept mapping tool and the continuing evolution of the tool. *Information Visualization*, 5(3), 175-184.
- Novak, J. D., & Cañas, A. J. (2006). The theory underlying concept maps and how to construct them. *Florida Institute for Human and Machine Cognition*, 1.
- Rohrbeck, C.A., Ginsburg-Block, M.D., Fantuzzo, J.W., Miller, T.R. (2003). Peer-assisted learning interventions with elementary school students: a meta-analytic review. *Journal of Educational Society*, 95(2), 240-257.
- Sharpley, A., Irvine, J., Sharpley, C. (1983). An examination of the effectiveness of a cross-age tutoring program in mathematics for elementary school children. *American Educational Research Journal*, 20(1), 101-111.
- Slavin, S. E. (1995). *Cooperative learning: Theory, research, and practice*. Needham Heights, MA: Allyn & Bacon.
- Spitzberg, B. H. (2006) Preliminary development of a model and measure of computer-mediated communication (CMC) competence. *Journal of Computer-Mediated Communication*, 11, 629-666.
- Utle, C. A., & Mortweet, S. L. (1997). Peer-mediated instruction and interventions. *Focus on Exceptional Children*, 29(5), 1-23.
- Vivian Wu, W.-C., Marek, M. W. & Huang, H.-W. (2012). *Using Skype and Facebook as Social Media to Enhance Learner Communicative Competency and Cultural Awareness in an EFL Advanced Conversation Class*. Paper presented at the 15th International CALL Research Conference, Taichung, Taiwan.
- Webb, N. (1989). Peer interaction and learning in small groups. *International Journal of Educational Research*, 13(1), 21-39.

Designing a Mobile Chinese Learning System with Speech Recognition for Foreign Students

Wei-Tung TANG^{a*} & Shwu-Ching YOUNG^b

^a*Institute of Information Systems and Applications , National TsingHua University, Taiwan*

^b*Institute of Learning Sciences, National TsingHua University, Taiwan*

**s100065531@m100.nthu.edu.tw*

Abstract: This study aims to design and implement a micro-learning Chinese vocabulary pronunciation practice system on mobile device for international students from a university in northern Taiwan. Learning a foreign language is difficult, yet using a foreign language to initiate social interaction with native speakers is even harder. In this study, we propose a location-based contextual Chinese learning system which aims to aid the foreign learners to learn daily life vocabulary by repeating practicing vocabulary pronunciation with speech recognition functionality. An immediate feedback will be shown to the learners, allowing them to check their correctness level of vocabulary pronunciation. To ensure the learning takes place in real context, the language learning will be enhanced with location-based service which is provided by Facebook. Location information will be available for the learners to access local tourist attraction information by selecting from nearby point-of-interests via Facebook's check-in module. An experiment will be conducted to measure students' language learning performance as well as their language learning motivation. We expect to recruit international students whose Chinese proficiency is at entry level. Participants will be selected from a northern Taiwan university.

Keywords: Mobile assisted language learning, automatic speech recognition, micro-learning, text to speech.

1. Introduction

As a modernized and globalized country, Taiwan has attracted numbers of foreign visitors here for various visiting purposes. Although English is a second language and a large proportion of Taiwanese citizens do understand it, many foreign visitors still find it difficult to blend in Taiwanese culture if they know absolute nothing about Chinese. “Learning Mandarin is considered to be difficult, and acquiring a deep understanding of Chinese culture is thought to be near to impossible.” (McKeon, 2009).

The education system in Taiwan has launched programs to support foreign students to continue their higher education for a long. National TsingHua University (NTHU) is one of the schools that accommodate nearly 3% of the total student population. One main issue that foreign students face is how they are going to adapt to a Chinese-speaking environment without assistance. We have observed that a large percentage of NTHU foreign students spend most of their time with similar culture groups. A foreign student from Africa once remarked Taiwanese students as “*smart, diligent, but less willingly to speak up*”. Another student also made such comment: “*Sometimes I have to take courses offered in Chinese. I have to sit there, listening to the Chinese lecture which I have absolutely no idea. After the class, I have only a few places to go, namely library, cafeteria or dormitory. Finally, I come to realize NTHU is just a school that gets me through four years college education.*” These learners cannot find the opportunities to interact with others, and do not have many chances to revise and adjust their Chinese speaking (Xin, 2001).

Second language learners can be divided into two different types based on their learning motivation. For people who seek to conquer the “language divide” by gaining a dominating language and improve their socioeconomic mobility, although their determination seems stronger than any others, they are likely to be frustrated by the needed time to master a foreign language, resulting in loss of learning interests. On the other hand, for those who are driven by intellectual-challenge or desire to initiate sustainable social interaction with target culture members, the learning curve for them is balanced, but it will require longer learning period. These two types of learners is the origin of “language divide”, which refers to the extra effort Chinese as Second Language (CSL) learners have to make to cross the language gap. For both groups of second language learners, the challenge is to maintain critical motivation and spend time in learning the target language in order to complete demands from work or social life (Dörnyei and Ottó, 1998).

With the sustained development of information technology (ICT), mobile phones now are equipped with downloadable applications. Integrating ICT into teaching and learning processes can make learners fully engage in learning tasks. (Agostini, Di and Loregian, 2010). Through mobile assisted language learning (MALL), now language learning is no longer limited to fixed location such as classrooms. With language learning application on mobile phone, learning can occur anytime, anywhere. Learning that occurs at increasingly spaced intervals will help learners remember what they have seen before. Such repetition will help them to recall information stored in short-term memory. Learning is enhanced when learners recall the learned detail rather than restudying it (Pashler, Rohrer, Cepeda and Carpenter, 2008). In this study, we propose an automatic speech recognition (ASR) system along with a text to speech (TTS) module, providing a way to conduct repeated practice between different time and places. We seek to integrate TTS and ASR modules with location-based service supported by Facebook. We expect the learners will be able to undergo micro-learning activity which deals with small learning units or short-term learning activities (Kovachev, Cao, Klamka and Jarke, 2011), and learn about daily life vocabulary with the real-life experience.

2. Purpose of the present study

The first aim of this study is to connect international students to the Chinese learning material, providing them a way to connect their lives to the local culture by learning how to identify vocabulary and based on a contextual learning scenario. Next, it is to identify the correctness level of Chinese vocabulary pronunciation with the aid of the proposed system design. There will be an attempt to examine learners' learning style and trend. Finally, it is to evaluate learners' willingness level of utilizing newly acquired vocabulary. Three research questions, corresponding to the purposes of this study will be addressed: (1) Would CSL learners' level of learning motivation be raised with the aid of the proposed location-based learning design? (2) Are there any preferred types of learning styles which lead to better learning outcome? (3) Does the immediate practice feedback have positive impact on CSL learners' Chinese vocabulary daily usage?

3. Literature Review

3.1 Current Chinese Language Learning Trend

According to American Council on the Teaching of Foreign Languages (ACTFL), there were only 5000 American high school students who took Mandarin Chinese as their secondary language in 2000. Yet, in 2007, there were more than 50,000 students who took Mandarin Chinese course. We understand that Mandarin Chinese has gotten more attention than it had before. Having that said, the number of students who have ambition to master Mandarin Chinese as their second language is still climbing high. Yet, it remains a mystery for most Chinese learners whether they are able to successfully cross the “language divide” or not.

3.2 Vocabulary Learning Strategy

Related researches indicated that, the ability to recognize vocabulary is the most basic and urgent one for all beginners (Ho, 2008; Sun, Huang and Liu, 2011). This applies to international students who pursue their higher education in Taiwan as well. Upon arriving in Taiwan, their life will be closely connected to this Chinese, sometimes Taiwanese speaking environment. If they do not manage to recognize some Chinese vocabulary, it is likely they will face a very difficult time during their stay. Moreover, recognizing the vocabulary is one thing, knowing how and when to use them is another, especially when most of Taiwanese feel comfortable speaking Chinese. Allowing the learners to understand how to apply the learned vocabulary to their daily life is crucial as an ideal Chinese teaching methodology. In addition to the language usage, applying sound and real-life context to the unfamiliar vocabulary will help the learners to remember it (Oxford, 1990). Learners should establish a meaningful connection between the unfamiliar vocabulary and their mother language as fast as possible, and then use multiple learning strategies and deep elaboration to make the information convert into unforgettable knowledge (Gu and Johnson, 1996). If we can associate unfamiliar vocabulary to real-life objects such as a coffee shop or a bus stop, and we have the learners listen to pronunciation of the vocabulary, language learning will be enhanced because next time the learners attempt to recall the information, the memory can be triggered by the associated pronunciation.

3.3 Adopting location-based service on mobile platform as a learning tool in situated learning

Most of established Chinese learning systems embrace the model of content delivery, which is dialog-based, story-telling and vocabulary flashcard. These types of learning systems aim to provide a scenario in which walk the user through the entire content of the course. “Let’s play Chinese Characters” is an example of using mobile games for children to learn stroke order of Chinese characters (Tian et al, 2010). For foreign Chinese learners, a context-aware mobile Chinese language learning system (CAMCLL) seeks solutions to solve real-life problem which low level Chinese learners might encounter by using context awareness technology (Al-Mekhlafi, Hu and Zheng, 2009).

An interesting cloud-based language learning system (Learn-as-you-go) uses tagging model to support Chinese learning. The authors seek to solve knowledge source management problem by offering its learners to fetch any web resource or service through cloud storage in their fingertips (Kovachev, Cao, Klamma and Jarke, 2011). Another systemsimilar to CAMCLL that uses location to support Chinese learning isMicroMandarin. The authors adopt a location-based social networking service “Foursquare” to determine learners’ location and push local information to them (Edge, Searle, Chiu, Zhao and Landay, 2011).

Although we have seen some interesting applications that assist learners to conduct ubiquitous learning outside of the classrooms, there is none offers automatic speech recognition. In our opinion, it is vital that the entry level Chinese learners verify their pronunciation of the learned vocabulary even with the help of situated learning. Without any guidance, students might mispronounce the characters until further correction made by peers or native speakers. Researches indicated that automatic speech recognition is able to lower learners’ anxiety level while attempting to learn new vocabulary, and further promote their learning motivation because they are aware of correctness level of their performance (Wang, Young and Jang, 2013). Darren et al (2011) also indicated that “Learning is best when performed through participatory experience”. Integrating location-based service with mobile assisted language learning (MALL) enhance learning experience by associating learning material to real-life objects (e.g. coffee shop, local cuisine, tourist attraction). When learners are enabled to associate abstract Chinese vocabulary to local objects, learning outcome will be amplified.

This study aim to establish a situated Chinese learning system based on location-based service supported by Facebook and automatic speech recognition technique. The proposed system will provide learners vocabulary pronunciation in a real-life context. Student will receive immediate

feedback on their pronunciation performance. The repeating vocabulary pronunciation practices which take place between different locations will help them retain real-life object Chinese information for future use.

4. Design of the mobile application

The design of this mobile application consists of 3 major functions:

(1) Location-based contextual language learning (2) Automatic speech recognition (pronunciation recognition & rating) (3) Text to speech (TTS) conversion. The implementation snapshots are shown in Figure 1.

First of all, when a learner logs onto their Facebook account, he or she will be redirected to the main user interface (see Figure 1a.). The centered map will show user's current location. The flickering blue dot indicates user's exact geography location. Upon pressing the pick-place button, the system will perform a nearby location check to determine learners' nearby location information. Learners then will be able to select the surrounding street objects to start acquiring new Chinese vocabulary (see Figure 1b).



(a) Main user interface (b) Street object selection (c) Learning content

Figure 1. Mobile Application User Interface Snapshots

Once a street object is selected, the corresponding street object will be shown to the learners. For this step, we adopt Google Text to Speechweb service to convert the street object string into a playable and repeatable mp3 file. The next step of the learning task, the learners are able to listen and record their pronunciation of the corresponding vocabulary (see Figure 1c). The corresponding street object image will also be shown. Automatic Speech Recognition (ASR) module will fetch the recorded sound file and send it back the processing server for performance evaluation. Finally, the result of learners' performance will be shown to them. Result will be graded in numbers. The application will also keep track how many times the learners has encountered the corresponding vocabulary.

The learning process is taking place in a real context where the learners can observe the objects while acquiring related vocabulary. As the authors of 3P-learning model indicate, learning is personal and self-directed. It is also driven by knowledge-pull. Learning also requires students' participation (Mohamed, Matthias and Marcus, 2010). In this proposed mobile application design, we apply 3P-learning model to the use of technology-enhanced language learning (TELL). Students can use it to acquire vocabulary according to their individual needs based on their current location. ASR module enables students to understand if they are on the track of learning by showing performance result to them. Students then will be able to use newly acquired vocabulary to initiate social interaction with native speakers. The location-based learning enables students to discover new knowledge that is crucial to their survival in a foreign country. The repeated pronunciation practices will gradually assist students to develop native-like speaking ability. Although this application do not provide regular classroom setting learning, students will have to go out there and interact with social context. We can this type of learning known as "Micro-learning". In this case, our learning process only takes place between learners' desired locations.

5. System Implementation

The mobile application will be implemented with various web development techniques and Apple iOS development SDK. It consists of Javascript Object Notation (JSON) and SQL database. Javascript will facilitate the communication between iOS and the SQL database. In addition, we will adopt Facebook Graph API as our location-based learning core module. The speech recognition is crucial for the application implementation. The ASR (Automatic Speech Recognition) toolbox is founded by Professor Jyh-Shiung Roger Jang (National Taiwan University, Taiwan). This core module is responsible for

deploying vocabulary soundtrack file playing and recording. After fetching learners' recorded file, it will be send back to the remote server for further performance analysis. Finally, the server will send back learners' performance feedback and score.

6. CONCLUSION

In this study, we have discussed our proposed mobile Chinese learning application. It is a system based on contextual learning in which learners can undergo their learning in a real-life context. With ASR module, learners will be provided with authentic Chinese pronunciation and tone which frequently troubles them. Learners will be provided with different real-life object and its information based on the location. Students' pronunciation will be corrected with ASR module, resulting in better performance. We expect our CSL learners to be less anxious when it comes to initiating social interaction with native speakers because they know they are speaking with correct pronunciation.

3. References

- Agostini, A., E. Di Biase, and M. Loregian. (2010). Stimulating cooperative and participative learning to match digital natives' needs, *8th IEEE International Conference on Pervasive Computing and Communications Workshops*, 274-279.
- Al-Mekhlafi, K, Hu, X. &Zheng, Z. (2009).An Approach toContext-Aware Mobile Chinese Language Learning forForeign Students.*Mobile Business*, 340–346
- Dörnyei, Z. &Ottó, I. (1998).Motivation in Action: A ProcessModel of L2 Motivation. Working Papers in AppliedLinguistics 4, 43–69.
- Edge, D., Searle, E., Chiu, K., Zhao, J., Landay, J.A.: MicroMandarin: Mobile Language Learning in Context. In: Proc. of CHI 2011, pp. 3169–3178. ACM (2011)
- Gu, Y., Johnson, R.K. (1996).Vocabulary Learning Strategies and Language LearningOutcomes. *Language Learning* 46(4), 643–679.

- Ho, W. C., Chang, C. Z. (2008). A Preliminary study of Chinese Learning Material for Oversea Chinese Young Children. *Annual conference of teaching Chinese as a second language*. Steering Committee for the Test of Proficiency- Huayu, Taipei.
- Hug, Theo (2005). Micro Learning and Narration. Exploring possibilities of utilization of narrations and storytelling for the designing of "micro units" and didactical micro-learning arrangements. Paper presented at the fourth Media in Transition conference, May 6–8, 2005, MIT, Cambridge (MA), USA.
- K.T. Sun, Y.M. Huang, M.C. Liu. (2011). A WordNet-based near-synonyms and similar-looking word learning system. *Educational Technology & Society*, 14 (1), pp. 121–134.
- Kovachev, D., Cao, Y., Klamma, R. and Jarke, M. (2011) 'Learn-as-you-go: New Ways of Cloud-Based Micro-Learning for the Mobile Web, H. Leung, et.al, (Eds), *ICWL 201*, Springer -Verlag, Berlin, , LNCS 7048, pp. 51-61
- M. A. Chatti, M. Jarke, and M. Specht. The 3p learning model. *Journal of Educational Technology & Society*, 13(4):74-85, 2010.
- McKeon, L (2009). Learning to speak Mandarin and understanding Chinese culture is different not difficult. Foucault: 25 years on. A conference hosted by the Centre for Post-colonial and Globalization Studies, Adelaide.
- Oxford, R. L (1990). Language learning strategies: What every teacher should know. Boston: *Heinle&Heinle Publishers*.
- Pashler, H., Rohrer, D., Cepeda, N. J., & Carpenter, S. K. (2007). Enhancing learning and retarding forgetting: Choices and consequences. *Psychonomic Bulletin and Review*, 14, 187–193.
- Tian, F., Lv, F., Wang, J., Wang, H., Luo, W., Kam, M., Setlur, V., Dai, G. & Canny, J. (2010). Let's play chinese characters: mobile learning approaches via culturally inspired group games. CHI'10, 1603–1612.
- Wang, Y. S., Young, S. S. –C., Jang, J. S., –R. (2013). Using Tangible Companions for Enhancing Learning English Conversation. *Journal of Educational Technology & Society*, 16(2), 296-309.
- Xin, S. C. (2001). The Chinese language reading strategy and research. Taipei, National Taiwan Normal University, Taipei, Taiwan.

Apples and Oranges? Second Life vs. OpenSim for Language Learning

Mark G. ELWELL^a, Jean-Christophe TERRILLON^b, and Steven A. COOK^b
Hakusan International School (Japan)^a, Japan Advanced Institute of Science and Technology^b
*markelwell@hakusaninternationalschool.com

Abstract: Shared virtual environments are used in technology enhanced language learning for their immersion, interactivity, and as a medium for both local and remote communication and contact with authentic speakers and situations. Previous work has shown them to achieve similar language learning outcomes to classroom situational role playing while using less time and other resources. Here we review the comparative suitability of two similar shared virtual environment platforms, Second Life and OpenSim, for language learning, using our SVECTAT (Shared Virtual Environment Complementing Task Achievement Training) model as a reference, and our extensive experience with the two platforms as a source. Features examined include collaborativity, cost, control, ease of use, scalability, and suitability for diverse learners. We find that while Second Life remains more suitable in certain specialized cases, OpenSim possesses clear advantages with regard to most features and cases.

Keywords: Collaborative learning, OpenSim, Role Playing, Second Life, Shared Virtual Environment, Technology Enhanced Language Learning

1. Introduction

Technology enhanced language learning (TELL) uses computers, networks, and related devices and media either to augment traditional language learning and teaching methods and materials, or to apply new methods and materials to language learning and teaching. Shared virtual environments (SVEs), such as massively multiplayer online games (MMOs), form one type of technological enhancement widely used and discussed in TELL.

One ground-breaking SVE is Second Life (SL), which is operated as a business by the company Linden Labs (LL), open to the public since 2003. OpenSim, a free and open source server program compatible with SL clients, has been available since 2008. Earlier work in SL (Elwell, et al, 2007) demonstrated its potential for use in language learning, leading to development of our Shared Virtual Environment Complementing Task Achievement Training (SVECTAT) method (Elwell, et al, 2009, Cook, et al, 2010, Elwell, et al, 2010).

Here we will review the comparative suitability of Second Life and OpenSim for language learning, using the theory and practice of SVECTAT as a reference, and extensive experience with both platforms as a primary source. We will examine and evaluate features including collaborativity, cost, control, ease of use, scalability, and suitability for diverse learners. We will first describe Second Life and OpenSim, and SVECTAT, next list, explain, and compare chosen features of SL and OpenSim, and discuss considerations for researchers, experimenters, and practitioners with reference to SVECTAT, then offer a conclusion and references.

2. Description of Second Life and OpenSim and of SVECTAT

2.1 Second Life

While the land, water, and sky in the shared virtual environment of Second Life are provided by LL, nearly all the content – sounds, animations, scripted functions, buildings, furniture, scenery, clothing, and avatar body parts – has been created, shared, and sold by and among users. Since 2006, making and operating a basic SL account has been free of charge.

The features that set Second Life apart and began to attract widespread attention and interest in about 2006 include: a *single shared, scalable environment* in which each of tens of thousands of users from all over

the world online at any given time could meet and interact with every other; privileges for paid premium users to *buy, rent, and sell virtual land* and for any user to rent from them; a *currency tradable both from and to US dollars*, enabling real business to be done using SL; *user ownership of content*, including buying and selling; real-time, in-world, *collaborative creation and editing* of content; and a *custom scripting language* for programming the behavior of objects and avatars.

Several of these features have made Second Life attractive for research, experimentation, and practice in language learning as well as many other fields (Elwell & Chang, 2010, Leigh, et al, 2010, Leigh & Elwell, 2010). To access, interact in, and create content for SL, one needs only a desktop or laptop computer with sufficient graphics capabilities for popular entertainment games, a free client program that operates on Linux, Macintosh, or Windows, and a broadband internet connection. A dedicated or even private space in SL can be rented from users or purchases directly from LL, allowing construction of persistent content for research, experimentation, or learning use.

Our own experience with Second Life dates to 2006, and has involved research into development of creative skills by users (Elwell, et al, 2007), development and testing of our own SVECTAT method of utilizing SVEs for English language learning, and more recently, collaboration with partners such as National Taiwan Normal University in constructing their Language Island for Chinese language learning.

2.2 OpenSim

OpenSim is a free and open source alternative server program compatible with SL viewers. The client software source code for Second Life is released openly after each new version, encouraging development of “third party viewer” SL clients by others. The server software source code for SL, however, is closed, preventing others from creating and hosting their own SL-compatible environments and making Second Life a “walled garden”.

OpenSim, being used with the same client programs as the SL server software, shares most of its distinctive features, including a *single shared, scalable environment*, *user ownership of content*, *collaborative creation and editing*, and the same *custom scripting language*. Since SL has a single sole operator, LL, and OpenSim can be operated by anyone at all, the rules, policies and practices of OpenSim environments vary widely. Like SL-compatible client programs, the OpenSim server program can be run, even in the background, on common computer hardware and broadband connections.

In addition to the features it shares with Second Life, OpenSim embodies a major element at first pursued by Linden Labs and then abandoned: *interoperability*, i.e., the ability for a user to log into one SVE and then transfer his avatar to another, with another computer host and operator, in a manner directly analogous to following a link in a web page to another site. This feature of OpenSim is called *hypergrid*, and is explicitly intended to foster a “3D web”.

Our own experience with OpenSim dates to 2008, and has involved development of self-hosted environments for use with SVECTAT, extensive use of OpenSim environments for prototyping of content, and collaboration with partners such as the University of Arizona on their Virtual Harlem project.

2.3 SVECTAT

Shared Virtual Environment Complementing Task Achievement Training (SVECTAT) is a model and method we have developed, tested, and presented in previous work using the shared virtual environment of Second Life to facilitate language learning. Authentic language tasks, such as getting contact information or directions, making a successful complaint, and holding an audience in the target language, face daunting challenges of authenticity and resource requirements – such as time and model speaker availability – when role-played in a traditional physical classroom.

SVECTAT has learners carry out the same tasks with authentic speakers in an immersive environment in Second Life, achieving similar language learning results in about half the time of task achievement exercises carried out in the physical classroom alone. SVECTAT also fosters collaboration, with each learner required to complete tasks individually, but with the support of peers and other people present in the shared virtual environment. The game-like structure has also been found to result in learners continuing beyond the specific tasks assigned in exercises to engage in independent target-language communications in the virtual environment.

3. Selected Features of SVEs for TELL

The features on which we will focus in this review are collaborativity, control, cost, ease of use, scalability, and suitability for diverse learners.

3.1 Collaborativity

Collaboration provides motivation, direction, and support for learning, and bridges the gap between sink-or-swim situations and confident independent knowledge, skills, and attitudes. The greater the facilities and opportunities for collaboration, the better for researchers, experimenters, and learners.

3.2 Control

Researchers, experimenters, and learners require control over their access to and use of a shared virtual environment if they are to rely on it for language learning. This includes being able to find or conduct fixes of technical problems in a timely manner.

3.3. Cost

Cost forms a substantial barrier to language learning in much of the world, where authentic communication with target language speakers is challenging or simply impractical to arrange. One of the greatest benefits of SVEs for language learning is bringing this affordance within reach to many more learners in many more cases.

3.4 Ease of Use

Client programs for shared virtual environments are designed to be similar in use to web browsers. Creators and operators of SVE locations, however, must consider their first time use by researchers, experimenters, or learners. Another consideration is the ease with which teams and groups can use an SVE location and its content.

3.5 Scalability

Among needs that can change in research, experimentation, and practice in language learning is the need for more or less space or content, matched to use by more or fewer persons. The speed, ease, and resource efficiency with this this can be done is a significant consideration in use of SVEs. Likewise, educational theory and practice currently face strong demands for scalability, especially for use in government school systems.

3.6 Suitability for Diverse Learners

Language learners can be of different ages, sexes, backgrounds, sensitivities, interests, and goals. This means that the content of a specific learning environment, including the appearance, behavior, and speech of people who may be encountered, must be suitable for specific cases.

4. Comparison of Second Life and OpenSim Features

4.1 Collaborativity

Second Life provides a venue and medium for collaboration using text chat, voice chat, and building, audiovisual enhancement, and scripting of objects. Since 2010, however, Linden Labs has announced new restrictions on ownership and use of objects in Second Life; both the new restrictions and their sudden implementation have led to significant numbers of object creators leaving the SVE, and to a widespread sense among users that LL is both arbitrary and unreliable.

There is now no practical way within the current SL Terms of Service for creators and owners of content to make backups of content created collaboratively in SL, or of venues constructed, for security or

other use. Likewise, users cannot back up or export their avatar inventories, often containing tens of thousands of items collaboratively created, received, or purchased over a period of years, without violating LL's Terms of Service.

The OpenSim software has all the same features relating to collaboration as Second Life. Additionally, backup features for regions and inventories are built into the software. Policies regarding ownership and use of content are in the hands of the operator of each OpenSim SVE.

In the case of SVECTAT, location operation and content creation or management was not involved, so the only difference between Second Life and OpenSim in this regard would be the presence of a greater number of user avatars in public spaces in Second Life, as opposed to even the most popular OpenSim based SVEs.

4.2 Control

Second Life had regular interruptions of service in its early years, but since 2008 is rarely inaccessible for more than a few hours at a time, and even that no more often than once or twice a month. On the other hand, problems requiring support, such as region settings or inventory access, are more common. LL's support is notoriously unreliable and slow. Requests for assistance can commonly languish for months before receiving any response, and many elements of operating a region cannot be adjusted except by LL.

Operating an OpenSim environment puts complete control of all elements of its operation in one's own hands. Regions can have settings changed, or be restarted, at any time. They and avatar inventories can likewise be backed up or restored at any time. When hosting is provided by others, that control rests with the operators, but same-day responses are typical, and several commercial OpenSim hosting providers include a web-based control panel for region owners that allows them to tend to their regions in the same way as if they hosted them themselves, but in a more user-friendly graphical way.

SVECTAT does not require control of a dedicated location, and may be conducted in either Second Life or OpenSim based environments if they are accessible.

4.3. Cost

A basic account for Second Life is free of charge, and allows users to visit public areas in the virtual environment and engage in visual, behavioral, text chat, and voice communication with others. Renting of virtual space to build customized venues varies in cost, but purchase of a 256m x 256m region from LL involves a US\$1,000 initial fee, followed by a maintenance fee of US\$300 per month; any failure to pay the maintenance fee can result in sudden and irreversible loss of the region and all content in it. Until 2012, LL offered a 50% discount to accredited educators for monthly land use fees, but suddenly withdrew it in the middle of an academic – and fiscal – year, causing serious difficulty and distress to most educators operating in SL. Most have left, and despite LL restoring the educational discount in 2013, few have returned.

OpenSim is free and open source software. Anyone, therefore, who can operate a Second Life compatible client can run OpenSim and host a shared virtual environment for no cost. For those lacking the technical or other resources to self-host, a variety of individuals, businesses, and institutions offer hosting services for OpenSim regions. Typically, these involve no starting fees, and monthly maintenance fees of between US\$0 and US\$90 for a 256m x 256m region.

SVECTAT can be conducted with free avatar accounts in either Second Life or an OpenSim SVE. Where adequate computer and network resources are present, its only cost is the time of instructors and facilitators.

4.4 Ease of Use

Second Life compatible client programs are designed to be similar to web browser in basic functions, and the main challenge in their use is in the number of features available and the different ways they are arranged in different clients and versions. There is no difference in this regard between Second Life and OpenSim, except that LL's official Second Life viewer connects only to Second Life, and is regarded as the worst of the most popular viewers for reliability and ease of use.

When operating a location in Second Life, other considerations arise. To control or filter access to and privileges for the general public, or for members of a specific group, involves a number of powers, some belonging only to one account designated as parcel or region owner by LL. Since SL's Terms of Service forbid

sharing accounts and account information, it becomes difficult or impractical for a group or institution to operate an SL location in response to quick-changing needs and situations.

Operators of OpenSim environments set their own policies, and can thus choose to allow sharing of accounts among groups of managers, making them much easier to operate and use for language learning.

SVECTAT requires an initial use of learning time to acclimate users to the SVE clients and environment; there is no significant difference in this regard between Second Life and OpenSim based environments.

4.5 Scalability

To increase or decrease the space used in Second Life involves dealing with user landlords or with LL. LL land use fees are paid in advance and are not refundable, so a sudden need to reduce one's land use may result in some or most of a month's fees being lost. Buying new regions from LL involves the costs discussed above; the US\$1,000 starting fee forms a high barrier to those uncertain if they need a region on a long-term basis.

If one self-hosts an OpenSim environment, scalability involves simply starting or terminating a session of the OpenSim program. If one obtains hosting from another operator, procedures and response will vary. Commercial hosting providers commonly provide a 24 hour turnaround. One, Kitley, provides hosting with a unique cloud-based system, serving only regions currently used by an avatar, and charging a per avatar hour rate; in theory, it should be able to smoothly scale up to concurrent use by very large numbers of learners.

The SVECTAT method is easily adapted for scalability, subject to the availability of adequate target language speakers in SVEs. On this point, Second Life currently has more concurrent users than all the publically available and hypergrid-linked OpenSim SVEs combined. On the other hand, Second Life users and activity have been stagnant or decreasing since 2008, and those of OpenSim SVEs growing steadily. The inherent advantage of OpenSim in terms of scalability is that nearly any computer can host an OpenSim SVE and link via hypergrid to *all* the others whose operators permit it. This is essentially unlimited scalability.

4.6 Suitability for Diverse Learners

Linden Labs has restricted access to Second Life based on age, preventing its use by younger learners. For teenagers and adults, even when resources are devoted to finding or maintaining suitable learning venues, the risk of accidental or intentional encounters with inappropriate content or behavior remains a significant concern.

OpenSim environments are operated with whatever policies chosen by those who run the server program. Access can be opened to the public, limited to specific individuals, or filtered in a variety of ways. For example, an OpenSim environment might be operated inside an institution's network, and be totally inaccessible over the internet. Likewise, content brought into an OpenSim environment can be limited or filtered by the operator.

In the case of our SVECTAT tests, we found that persons encountered in open social venues in Second Life tended to be friendly, helpful, and open to participating in exercises with our learners. On the other hand, we also found that even with adult (graduate student) learners, content and behavior of some SL users, especially when voice communication was included, could offend, shock, or even frighten some learners, leading to failure of the exercise.

Evaluating this comparison, we find that in cases where every learner is 16 years old or older, and is comfortable with the possibility of encountering any type of content or behavior, Second Life has the advantage of a wide and deep variety of locations and content, and above all, a large population of tens of thousands of potential interlocutors at any time. In all other cases, however, the risk of a learner encountering inappropriate content or behavior is sufficiently serious to strongly indicate hosting or selecting an OpenSim environment.

5. Discussion

Goals and considerations for individual cases of research, experimentation, and practice in language learning will necessarily vary widely. It is therefore not practical or useful to attempt to derive a single rubric indicating for all cases the use of Second Life or of OpenSim. Instead, our findings are hoped to provide useful indications for the comparative suitability of one or the other SVE platform in particular cases.

In Table 1, our findings are presented with reference to general technology enhanced language learning cases and to SVECTAT. For general TELL cases, Second Life and OpenSim are assessed in their suitability. For SVECTAT, an indication of greater suitability for one or the other SVE platform is listed for each feature (collaborativity, control, cost, ease of use, scalability, and suitability for diverse learners).

Table 1: Comparative Suitability of Second Life and OpenSim for TELL and SVECTAT

General TELL cases	Second Life	OpenSim	SVECTAT
Collaborativity	Strong, weakening	Strong, strengthening	Second Life slightly
Control	Weak, weakening	Very strong	No difference
Cost	Moderate to high	Low to none	No difference
Ease of Use	Moderate to weak	Moderate to strong	No difference
Scalability	Weak	Very strong	Second Life slightly
Diverse Learner Suitability	Difficult to ensure	Easy to ensure	OpenSim strongly

6. Conclusion

We have reviewed the comparative suitability of Second Life and OpenSim for language learning, using the theory and practice of SVECTAT as a reference and extensive experience with the two platforms as a primary source. We examined and evaluated features including collaborativity, cost, control, ease of use, scalability, and suitability for diverse learners. We found that for a minority of cases, Second Life continues to be more suitable, but that for a majority, and especially with regard to control, cost, and especially scalability and suitability for diverse learners, OpenSim based shared virtual environments are strongly indicated.

These findings are significant for researchers, experimenters, and learners seeking to gain the benefits of shared virtual environments for language learning, such as immersion, collaboration, and opportunity for authentic communication with target language speakers.

Comparative testing of SVECTAT in Second Life and OpenSim environments, and of other language learning methods and exercises, to glean quantitative results, is indicated for future work.

References

- Cook, S., Elwell, M., & Leigh, M. (2010). Classroom Learning, Virtual World Application – Developing the SVECTAT Method. Proceedings of the 18th International Conference on Computers in Education. Putrajaya, Malaysia.
- Elwell, M., Cook, S., & Medeni, T. (2007). Creative Skill Learning in Second Life. Paper presented at the *Workshop on Fun and Learning: Should Educational Games and Toys Be Serious?* In Proceedings of the 15th International Conference on Computers in Education, Hiroshima, Japan.
- Elwell, M., Cook, S., LEIGH, M., & Terrillon, J. C. (2009). Shared Virtual Environment Complementing Task Achievement Training. In Proceedings of the 17th International Conference on Computers in Education, Hong Kong.
- Elwell, M. & Chang, B. (2010, January). Mission-Oriented Situated Second Language Learning in Second Life. IEEE Learning Technology Newsletter, 12(1). 62-65.
- Elwell, M., Cook, S., Leigh, M., & Elwell, M. (2010). Around the Worlds-Testing the SVECTAT Method. In Workshop Proceedings of the 18th International Conference on Computers in Education: ICCE2010 (p. 268).
- Leigh, M., Elwell, M. G., & Cook, S. (2010, April). Recreating Ancient Egyptian Culture in Second Life. In Digital Game and Intelligent Toy Enhanced Learning (DIGITEL), 2010 Third IEEE International Conference on (pp. 114-118). IEEE.
- Leigh, M., & Elwell, M. (2010). Authentic Theurgy: Ceremonial Magic in Second Life. In Workshop Proceedings of the 18th International Conference on Computers in Education: ICCE2010 (p. 260).

A Cooperative Learning Platform for Context-aware Ubiquitous Learning: A Pilot Study of Mandarin Chinese Learning Activities

Szu-Yun WANG^a, Yu-Ju LAN^{a*}, Yao-Ming YEH^b, Jen-Shing LIN^a, Yao-Ting SUNG^c

^a*Department of Applied Chinese Language and Culture, National Taiwan Normal University, Taiwan*

^b*Department of Computer Science & Information Engineering, National Taiwan Normal University, Taiwan*

^c*Department of Educational Psychology and Counseling, National Taiwan Normal University, Taiwan*
***yujulan@gmail.com**

Abstract: This pilot study aimed at examining the effects of a context-aware ubiquitous system on overseas Chinese students' Mandarin Chinese learning. The research was undertaken on 49 CFL learners of Chinese descent, with whom we conducted interviews regarding their experience using the mobile learning system. It was discovered that the CFL learners found the new learning system both more interesting and informative than conventional teaching methods, but also pointed out several correctable flaws and technical defects which hampered the learning process.

Keywords: Mobile learning, app, eBook, CSL, CFL, cooperative/collaborative learning

1. Introduction

Due to the rapid development of technology and the increased population of wireless communication, research about mobile learning (m-learning) has been conducted increasingly over the past decade (Hwang & Tsai, 2011). They have also pointed out the importance of further study on m-learning to facilitate learning.

M-learning is also proven to benefit learning in many aspects, such as increasing young adults' motivation (Attewell & Webster, 2004). Hence, using mobile devices to support learning has raised more open possibilities for learners to access learning activities anywhere and anytime with the assistance of supportive learning materials and real-time feedback (Lan, Sung & Chang, 2007). Furthermore, Lan et al. (2007) suggested that m-learning reduces learners' stress in cooperative reading activities, and particularly low- and medium-level learners showed a high level of concentration on reading tasks.

Therefore, the purpose of this pilot study was to examine the effectiveness and viability of a new Mandarin learning system in development for use on mobile devices, and to promote a more effective system for Mandarin learners.

2. Methodology

2.1 Participants

Forty-nine teenagers of Chinese descent from mostly Europe and America, whose first languages (L1) or home languages are not Mandarin, participated in the pilot study. Due to their family background, most of them have one or two parents from a Chinese speaking country, such as China or Taiwan. Some of their parents or other family members speak Mandarin to them. However, they have fewer opportunities to read and write Chinese due to the general environment in their own countries. Thus, their Chinese oral proficiency might be near fluent while their Chinese written language (reading and writing) and vocabulary size are relatively limited.

2.2 Research Design

This pilot study used a qualitative approach to investigate how effectively the new system works by conducting an experiment where Chinese learners utilized the system to finish a collaborative learning activity. This experiment allowed us to pinpoint what needs to be improved and changed in the system of both learning process and technical issues.

2.3 Instrument

In this experiment, we designed a Mandarin learning activity designed for use on a recently developed Mandarin learning app for mobile devices as well as for the eBook platform on computer for Chinese as Second Language (CSL) learners (see Figure 2-c for the system screen shot). Each student was given a tablet computer (Eee Pad Transformer Prime TF201) and had access to the lab computer to finish the learning task they were given.

2.4 Procedure

The participants were given a training session before the formal learning activity. After the training session, the participants were divided into small groups of 3-5 people. The formal activity proceeded as the following illustration:

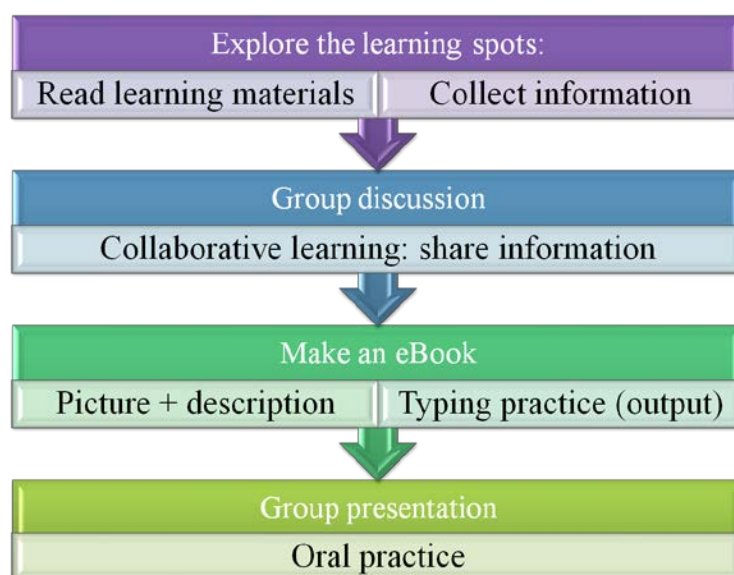


Figure 1. The process of the designed learning activity.

Field Notes – From the Observers’ Perspective

The researchers took field notes of every small group in every class regarding the phenomenon they had observed during the whole learning activity, which included the technical issues they had encountered, learning problems they had experienced, and all circumstances they had observed.

Semi-structured Interview questionnaire

After the learning activity, participants were randomly chosen and interviewed after the learning activity to investigate their attitudes toward the learning system and materials. Some open-ended questions were designed for this semi-structured interview regarding the following aspects: participants’ background, how they felt about the learning activity, if the learning materials were suitable, if the app and eBook system were user-friendly and what flaws and technical defects were there we can revamp to improve the learning process.



Figure 2. The pictures taken during learning activity.

3. Results

From this pilot study, we have learned valuable facts which continue to help us improve this learning system.

3.1 Interesting and Attractive Ideal to Learn a New Language for Young Adults

Most participants in this experiment liked the idea of the learning activity and referred to it as “interesting and useful”. Due to the trend of the increasing population of smart phones, mobile devices such as tablet computers are not foreign to young learners. Participants pointed out that this learning activity was amusing to them because it involved more engaging exercises than traditional classroom. For instance, many participants enjoyed taking pictures and exploring the learning spots because it was interesting and “special” to them. Some of them mentioned that they practiced more in speaking in Chinese presentations, and making an eBook offered them more opportunities to practice in typing Chinese characters, which are less taught in traditional classroom but useful in practice.

The idea of mobile learning is attractive to teenage students, and most of them thought this learning system was recommendable, especially if some current issues could be solved. However, as previously mentioned, we have also noticed some issues from both the users’ and observers’ perspective. The following presents these issues from both the aspects of learning material design and technical issues.

3.2 Technical defects and flaws that require improvement

3.2.1 Learning Material issues

- The learning materials need to be simpler and more supportive.
- There was not enough time to finish the reading materials of the learning spots.
- The reading materials need to be less complicated or shorter since reading Chinese characters could be time-consuming for non-native speakers.
- The learning material design need to suit students’ interests so students could be more motivated.

Technical issues

- The system needs to be more user-friendly, such as the interface of the app and eBook.

- A clear guild line is needed to lead users about how to use the app and eBook system.
- Internet quality is important for mobile learning in this case. The participants encountered the problem of being disconnected from the internet and thus needed to keep re-connecting. Because of this issue, the learning activity kept getting interrupted.
- To avoid the internet issue, the system needs a mechanism that will automatically save pictures on the mobile device, and then later upload them when an internet connection again becomes available.

4. Conclusion

This pilot study provides a great opportunity to evaluate the new Mandarin learning system in development from both instructors' and users' perspective. It provides a good starting point for both the learning material design as well as for the development of the app and eBook system.

However, there is still much room to improve this learning system. By examining the flaws and issues with the initial system design, we will be able to draw guidelines that lay the foundation for an even better future iteration of this teaching method.

Acknowledgements

The authors would like to thank the National Science Council of the Republic of China, Taiwan, for financially supporting this research under Contract Nos. NSC 101-2511-S-003-031-MY3, 101WFA0300229, and NSC97-2631-S-003-002. The authors also want to thank the Ministry of Education of the Republic of China, Taiwan, for financially supporting this research under Aim for the Top University Plan."

References :

- Attewell, J., & Webster, T. (2004). Engaging and supporting mobile learners. In Proceedings of MLEARNING 2004: Mobile learning anytime everywhere (pp. 15-20). London, UK: Learning and Skills Development Agency.
- Hwang, G. J. & Tsai, C. C. (2011). Research trends in mobile and ubiquitous learning: a review of publications in selected journals from 2001 to 2010. *British Journal of Educational Technology*, 42, 4, E65–E70.
- Lan, Y. J., Sung, Y. T., & Chang, K. E. (2007). A mobile-devices-supported peer-assisted learning system for collaborative early EFL reading. *Language Learning & Technology*. 11(3), 130-151.

Bridging the Past and the Future of the Research in Seamless Learning

Lung-Hsiang WONG*

Learning Sciences Lab., National Institute of Education, Nanyang Technological University, Singapore

*lunghsiang.wong@nie.edu.sg

Abstract: This paper centers on an account of the research foci of MSL according to my recent literature scan and analysis. 83 relevant papers published between 2006 and April 2013 were identified for analysis. However, it is not our intention to compile thick and intentionally accurate statistics, and subsequently offer purely data-driven interpretation of the state of the arts. Rather, we are keen on qualitatively outlining and tracing the evolution of MSL research, particularly in how scholars perceive the roles of technology, pedagogy, learning spaces, and learners in the seamless learning practices. This paper will focus on (1) the (re-)scoping of seamless learning; and (2) the conceptual groundings in the past MSL research. Rise-above discussions on the trends will then ensue in order to provide a synoptic picture of how this line of studies have been advancing over the time. Through the analysis, it is further affirmative that seamless learning is much more than a special form of any other learning method. It is a learning approach at its own right and with its own niche – with ‘bridging of cross-space learning efforts’ as its distinctive feature.

Keywords: Mobile seamless learning; literature review; conceptual groundings

1. Introduction

Seamless learning has two lives – one is in the field of higher education studies and another in technology-enhanced learning (TEL), particularly mobile and ubiquitous learning (m-learning and u-learning). The two ‘lives’ were ‘born’ more than a decade apart - in early-1990s and mid-2000s, flourished by the seminal papers, Kuh (1996) and Chan et al. (2006), respectively. Nevertheless, the two ‘lives’ have barely been ‘interacting’ with each other (i.e., almost no cross-citation) until 2011 despite bearing an identical name.

The first life of seamless learning began with higher education scholars and leaders’ questioning of the gap between the roles of faculty and student affairs professionals (Bloland, Stamatakos, & Rogers, 1994), reflecting two domains of student life – in the classroom and out of the classroom (Kezar, 2003). As a result, they re-examined the need for integration of these roles and advocated a change in the culture of learning from separatist to seamless (e.g., American College Personnel Association, 1994; Knefelkamp, 1991) orientation. Picking up from there, Kuh (1996) elaborated the notion by extending it to involve off-campus experiences, “In seamless learning environments, students are encouraged to take advantage of learning resources that exist both inside and outside of the classroom. Students are asked to use their life experiences to make meaning of material introduced in classes.” (p. 136)

With the coming of the 21st century, scholars in the emerging field of m/u-learning has begun to snap to the notion of seamless learning and coin the term in the relevant literature (e.g., Cheng, Sun, Kansen, Huang, & He, 2005; Thomas, Schott, & Kambouri, 2004), with a greater focus on technological innovation to enable specific personalized learning activities across spaces. With the proliferation of 1:1 (one-device-or-more-per-student) setting, an international synthesis of the topic by Chan et al. (2006), saw seamless learning being re-framed in the context of TEL as “... the continuity of the learning experience across different scenarios or contexts, and emerging from the availability of one device or more per student.” (p.23)

The paper has virtually launched the ‘second life’ of seamless learning with follow-up discussions and studies taking place within the community of m/u-learning. This ‘second life’ is retrospectively known as ‘mobile-assisted seamless learning’ (MSL) by Wong and Looi (2011) to

differentiate from its ‘first life’ or the general sense of seamless learning. Although the ‘second life’ can be seen as a ‘cousin’ of the first to begin with, it is then aggressively evolving and identifying its own niche, and enriching the meaning of the fundamental notion.

This paper centers on an account of the research foci of MSL (the ‘second life’) according to our recent literature scan and analysis. The approach in identifying the relevant papers was similar to what was employed by Wong and Looi (2011). We started with rounds of searches on Google Scholar, ERIC, Web of Knowledge and British Education Index, with the Boolean combination of search keywords [“seamless learning” AND (“mobile learning” OR “ubiquitous learning” OR “handheld”)]. 83 papers were identified, i.e., an addition of 29 recent publications on top of what were reviewed by Wong and Looi (2011). However, it is not our intention to compile thick and intentionally accurate statistics, and subsequently offer purely data-driven interpretation of the state of the arts. Rather, we are keen on qualitatively outlining and tracing the evolution of MSL research, particularly in how scholars perceive the roles of technology, pedagogy, learning spaces, and learners themselves in the seamless learning practices. Due to the space constraint, this paper will focus on (1) the (re-)scoping of seamless learning; and (2) the conceptual groundings in the past MSL research. In a forthcoming book chapter (Wong, forthcoming), we will further present the MSL-specific theoretical, characterization, ecological, design, methodological and technological frameworks being developed in the past 7 years. Rise-above discussions on the trends will then ensue to provide a synoptic picture of how this line of studies have been evolving and advancing over the time.

2. Scoping and Re-scoping Seamless Learning

Despite having rich literature in its ‘first life’, seamless learning is often seen as a special form of m/u-learning within the TEL community. Some TEL researchers carried a relatively techno-centric perspectives that treated ubiquitous and context-aware technologies as the essential enablers of MSL without being interrupted while learners switch locations or devices (Hwang, Tsai, & Yang, 2008; Yu, Yang, & Cheng, 2009). Others viewed seamless learning and ubiquitous learning as synonyms (Ng & Nicholas, 2007; Wang & Wang, 2008). Wong and Looi (2011) did not concur with both views as u-learning is a relatively techno-oriented notion about how ubiquitous technology supports learners in the right way, in the right place, and at the right time, based on the personal and environmental contexts in the real world (Hwang et al., 2008). To clarify the distinction between u-learning and MSL, it is good to examine some representative ‘scoping descriptions’ of MSL in the literature, as shown in Table 1.

Table 1: Representative ‘scoping descriptions’ of MSL in the literature

Publication	Scoping Description
Chan et al. (2006)	“...marked by continuity of the learning experience across different scenarios or contexts, and emerging from the availability of one device or more per student. By enabling learners to learn whenever they are curious and seamlessly switch between different contexts, such as between formal and informal contexts and between individual and social learning, and by extending the social spaces in which learners interact with each other, these developments, supported by theories of social learning, situated learning, and knowledge-building, will influence the nature, the process and the outcomes of learning.” (p. 23)
Yang (2006)	“The ubiquitous learning environment can connect, integrate and share learning resources in the right place at the right time by an interoperable, pervasive and seamless learning architecture.” (p.188)
Ng & Nicholas (2007)	“Sharples, Taylor and Vavoula (forthcoming) [<i>note: (Sharples, Taylor, & Vavoula, 2007)</i>] have proposed a model of learning for the mobile age, but we argue that their model omits one important consideration ... they have highlighted the physical ubiquity of the technology without adequate consideration of the conditions for seamless learning. In presenting their model, they continue a perhaps unconscious tradition of the mobile learning field to highlight mobility over learning. Our argument is that at least in the mainstream school education context, seamless learning requires planned interactions between mobile and stable technologies.” (pp.3-4)
Chiu et al. (2008)	“Ubiquitous learning environments enable seamless learning at anywhere and anytime. The learners are allowed to learn without being interrupted while moving from place to place.” (p.259)
Hwang et al. (2008)	“A context-aware ubiquitous learning environment enables seamless learning from place to place within the predefined area.” (p.84)
Rogers &	(<i>Note: This appears to be a synthetic definition for m-learning, u-learning and MSL.</i>) “Central to

Price (2009)	these notions is the idea that mobile technologies can be designed to enable children to move in and out of overlapping physical, digital and communicative spaces. The mobility can be achieved individually, in pairs, in small groups, or as a whole classroom ...” (pp.4-5)
Obisat & Hattab (2009)	“The modern e-learning system must be able to offer personalized support and learning solutions in real-time. Such an approach combines real-time assessment, learning, and pedagogical considerations into one seamless learning activity.” (p.126)
Baloian & Zurita (2012)	“The ubiquitous availability of mobile devices promotes the seamless learning notion that envisages the embodiment of learning into everyday living.” (p.7000)
Wong (2012)	“There may be episodic learning efforts taking place in different contexts, either externally facilitated (e.g., started from a teacher) or self-initiated. However, such isolated learning gains may later be converged as they may mediate the same learner’s learning efforts in the future.” (p.E20)
Wong (2013)	“We re-conceptualize the nature of ‘seamless learning environment’ from an individual learner’s perspective by adapting Barron’s (2006) definition of learning ecology as ‘the combination of physical or virtual (living) spaces that a person is situated or encounters in his/her daily life that provides opportunities of learning.’” (p.209) “... to re-conceptualize the nature of seamless learning from an individual learner’s perspective, i.e., students’ self-generation of learning contexts within and across their living spaces. Students should ultimately become life-long autonomous learners who are able to decide when, where and how to learn with self-identified resources within their learning spaces.” (p.210)
Milrad et al. (2013)	“... genuine seamless learning is about treating all the learning spaces and resources that learners have access to as ingredients to facilitate their ongoing self- and co-construction of knowledge, rather than believing in knowledge as composed of universal facts that are best learned through didactic teaching.”
Looi & Wong (in-press-a)	“A more productive view of learning sees learning as happening continuously over time and learning experiences as being enriched when similar or related phenomena are studied or seen from multiple perspectives. In more formal settings, learners may learn canonical knowledge about a subject or topic, while in more informal settings, learners experience the subject or topic in its natural settings or in different contexts, thus achieving more holistic notions of learning and literacy. Learners will almost naturally and continually enhance their knowledge and skills to address problems and participate in a process of continuous learning.”
Sharples et al. (2012)	“Seamless learning is when a person experiences a continuity of learning across a combination of locations, times, technologies or social settings.” (p.24) “Seamless learning may form part of a wider learning journey that spans a person’s life transitions, such as from school to university or workplace.” (p.24) “Seamless learning can best be seen as an aspiration rather than a bundle of activities, resources and challenges.” (p.25)
Toh, So, Seow, Chen, and Looi (2013)	“This notion of seamless learning refers to the integrated and synergistic effects of learning in both formal and informal settings, which is distributed across different learning processes (emergent or planned) as well as across different spaces (in or out of class).”

The expositions of Chiu et al. (2008) and Hwang et al. (2008) seem to be contradictory as the former talks about ‘anytime, anywhere learning’ while the latter stipulates ‘learning within a predefined area’. Hwang et al.’s (2008) exposition is perhaps pertaining to one of the well-studied solutions of u-learning environments that leverage location-based services to tailor learning trails to a specific location or specific objects (e.g., those using RFID or QR tags). Examples of such MSL interventions are also reported in Kurti, Spikol and Milrad (2008), Rogers and Price (2008), and Shih and Tseng (2009). In contrast, the Global Positioning Systems (GPS) or the Geographic Information Systems (GIS) helps the MSL designers and learners in breaking the barrier and affording learning activities to be carried out perhaps in much wider areas. MSL designs that adopted the technologies are accounted in Maldonado and Pea (2010), Ogata et al. (2008), and Sollervall and Milrad (2012), etc.

In a broader view, ‘learning anytime, anywhere’ was once a ‘slogan’ for e-learning in general, and later being taken over by m-learning. The question here is that is ‘learning anytime, anywhere’ equal to ‘continuity of learning across multiple spaces’? If so, the seamless learning notion would not have its own niche. Indeed, we see some of the reported interventions were loosely characterized in the literature as seamless learning designs. Yet the learning activities were somewhat repetitive, perhaps in a behaviorist manner, albeit across time and spaces (e.g., Huang et al., 2007; Miyata, Sannomiya, &

Suzuki, 2010; Narayanansamy & Ismail, 2011; Tillman et al., 2012). The way we see such an approach is, however, that it fall back to the ‘classic’ e-learning construct of ‘learning anytime, anywhere’ without the consideration of what unique environmental constructs in varied learning spaces including artifacts, tools and/or people could offer to facilitate multifaceted learning tasks – e.g., physical spaces for situated learning and authentic data collection, online platforms for peer discussions, etc.

Subsequent studies then began to accentuate the natures of and the roles that various learning spaces may play in mediating the seamless learning journeys. Both Rogers and Price (2009) and Baloian and Zurita (2012) coined the term ‘embodiment’ to underscore the importance of mobile and seamless learners’ blending into, and interacting and having conversations with, the physical and social worlds (or, ‘everyday living’). This marks a departure from the earlier ubiquitous technology-driven interventions which typically treated learners as passive ‘consumers’ of (perceived static) physical contexts (Whitworth, 2008; Wong, 2013). The arguments are also consistent with what Pea (2009) postulated, “We need to treat the activities and life experiences of the learners throughout the day as our units of learning design, description and explanation.”

Whereas ‘learning in the right way at the right space and the right time’ seems to be the key to general m-learning and situated learning, perhaps the defining feature of seamless learning is ‘bridging’ the multifaceted learning efforts across learning spaces. Building on the quote from Wong (2012) in Table 1, Wong (in-press) envisaged a spiral-style construct across MSL tasks (or, ‘learning cycles’ in the paper) where “in the present cycle, the explicit target knowledge to learn, the learning activity types, the skill to learn and apply, the mobile affordances to use, and the student artifacts to reuse and create, are all building on or rising above the previous cycle.” Without such an ‘organic’ bridging of learning experiences and learning gains despite enactments of a variety of learning tasks across spaces, one’s learning journey will remain fragmented, if not repetitive.

As observed by Marcelo et al. (2013), “recent studies on seamless learning have been extending from teacher-facilitated classroom or outdoor learning into nurturing autonomous learners.” (p.96) Seamless learning is now seen as an aspiration (Sharples et al., 2012), a ‘habit-of-mind’ (Wong & Looi, 2011), or ‘schematized and habitual regulatory strategies’ in psychological term (Sha, Looi, Chen, & Zhang, 2012) that should span one’s lifetime and make one become a life-long learner. With more and more level- or institution-wide 1:1, 24x7 initiatives being implemented (Bentley, Shegunshi, & Scannell, 2010; Looi & Wong, in-press-b; Ng & Nicholas, 2009; Pegrum, Oakley, & Faulkner, 2013; Vogel, Kennedy, Kuan, Kwok, & Lai, 2007), the fostering of a culture of seamless learning is now on the table.

In a nutshell, the trajectory of evolution of the seamless learning notion probably signifies that the practice of this notion should go beyond the mindset of offering learners the ‘logistic convenience’ in contextual and cross-contextual learning. The key is to facilitate and nurture genuine transformations of beliefs about and habits of learning among the learners. Ultimately, if a one-statement definition of seamless learning is still desired, perhaps we can adopt and adapt from Sharples et al.’s (2012, p. 24) exposition,

“Seamless learning is when a person experiences a continuity of learning, *and consciously bridges the multifaceted learning efforts*, across a combination of locations, times, technologies or social settings.”

We insert the ‘bridging’ element into the exposition since ‘a continuity of learning’ alone does not necessarily encapsulate the stated condition – even the above-stated ‘learning anytime, anywhere(, repetitively)’ designs may fit this description. With this relatively concise definition (though perhaps requiring further unpacking), the field would not need to always quote the wordy ‘scoping description’ as put forward by Chan et al. (2006).

3. The Conceptual Groundings

Seamless learning or MSL has been loosely referred to by some literature as a learning *theory* (e.g., Fang, Wang, & Huang, 2011; Tsoi & Dekhane, 2011). However, just like inquiry learning and m-learning, seamless learning should instead be seen as a learning notion or a learning approach at least till it is convincingly theorized. To start with, Chan et al. (2006) was meant to be an initial

characterization effort on MSL as a rise above of the co-authors' synoptic and critical analysis of the state-of-the-arts of general m-learning. Over the years, scattered work on modeling, framework building and initial theorization of MSL took place, which will be synoptically presented in our forthcoming book chapter. For now, let's survey existing general learning theories, frameworks and concepts that the MSL researchers have rooted their studies in. This would assist us in making better sense of the nature of seamless learning and shed light on the future research and practical directions of the field.

A summary of the types of conceptual grounding is given in Table 2. Note that papers with brief mentioning of certain conceptual groundings without clear evidences of their actual designs or analysis being informed by the stated concepts are *not* included in the table.

The first set of MSL studies, typically those which are technology innovation-oriented, have exhibited the tendency of associating their intervention designs to numerous TEL concepts or approaches, such as m/u-learning in general, pervasive learning, distance learning, blended learning, personalized learning or Personalized Learning Environment (PLE), and ICT as cognitive tools. Also being rooted for learning designs are context-awareness/sensitivity/ adaptivity, which are more general technological architectures than learning approaches.

The second set of studies was framed by the common characteristic of foregrounding the roles of learning spaces or scenarios in mediating learners' deep learning, such as situated learning, authentic learning, experiential learning, scenario-based learning, and conversation theory. Nonetheless, the theoretical framings assumed by some of these studies appeared to be more orientated towards general m/u-learning than seamless learning. Experiential learning is perhaps the only learning notion among the stated ones that inherently encapsulates the essence of seamless learning. Guided by Kolb's (1984) four-task cyclical model for experiential learning (concrete experience, reflective observation, abstract conceptualization, and testing in new situations), two MSL studies (Lai, Yang, Chen, Ho, & Chan, 2007; Song, Wong, & Looi, 2012) designed learning flows with the four learning tasks being carried out and *bridged* across multiple learning spaces.

Table 2: The conceptual groundings of seamless learning adopted by the literature

Category	Conceptual Grounding	Referencing Literature
TEL concepts or approaches	m/u-learning (in general)	Hwang et al. (2008); Ng & Nicholas (2007); Shih, Chu, Hwang & Kinshuk (2010); Wyeth et al. (2008)
	Pervasive learning	Bouzeghoub, Garlatti, Do & Pham-Nguyen (2011); Khan & Zia (2007)
	Distance learning / blended learning	Bentley et al. (2010)
	Personalized learning or PLE	Bentley et al. (2010); Gillot, Garlatti, Rebai & Pham-Nguyen (2012); Looi et al. (2009); Obisat & Hattab (2009); Tabuenca, Ternier & Specht (2012)
	ICT as cognitive tools	Seow, Zhang, Chen, Looi, & Tan (2009)
	Context-awareness / context-sensitivity / context-adaptivity	Li, Feng, Zhou & Shi (2009); Yu et al. (2009); Zhao & Okamoto (2011)
Learning notions that foreground the roles of learning spaces (contexts)	Situated learning	Buzeghoub et al. (2011); Chen, Kinshuk, Wei & Yang (2008); Kurti et al. (2008); Metcalf, Milrad, Cheek, Raasch & Hamilton (2008); So, Tan & Tay (2012); Zurita & Baloian (2012)
	Authentic learning	Ogata et al. (2008)
	Experiential learning	Lai, Yang, Chen, Ho & Chan (2007); Song, Wong & Looi (2012)
	Scenario-based learning	Metcalf et al. (2008)
	Conversation theory	Zhao & Okamoto (2011)
	Distributed cognition	Looi et al. (2010); Otero et al. (2011); Seow et al. (2009);

		Song (2013); Wong, Chen & Jan (2012)
Pedagogic- or constructivist-inspired notions	Socio-constructivism	Roger & Price (2008); Spikol & Milrad (2008)
	Knowledge building	Maldonado & Pea (2010); So et al. (2012)
	Knowledge spirals	Zhang & Maesako (2009)
	Inquiry learning	Gillot et al. (2012); Maldonado & Pea (2010); Rogers & Price (2008)
	Sense/meaning making	Toh et al. (in-press); Wong, Chin, Tan & Liu (2010)
	Learner-generated contexts	Wong (2013)
	Learning with patterns	Zurita & Baloian (2012)
	Cognitive apprenticeship	Zurita & Baloian (2012)
	Scaffolding	Lin, Chen & Chen (2008)
	Differentiated instructions	Looi et al. (2009)
	SECI model	Chang & Chen (2007); Zhang & Maesako (2009); Baloian & Zurita (2012)
Autonomous learning approaches	Self-guided exploration	Vogel et al. (2007)
	Self-directed learning	El-Bishouty, Ogata, Ayala & Yano (2010); Wong (in-press); Zhang et al. (2010)
	Lifelong learning	Tabuenca et al. (2012)
	Transformation of participation	Toh et al. (in-press)

A pertinent notion is distributed cognition (DCog) which has provided the grounding for the second largest set of MSL studies among all the relevant theoretical underpinnings (five of them; after situated learning with seven; see Table 2). DCog is devoted to the study of the representation of knowledge both inside the heads of individuals and in the world, the propagation of knowledge between different individuals and artifacts (broadly defined to include instruments, signs, languages and machines that mediate activities) and the transformations that external structures undergo when operated by individuals and artifacts (Flor & Hutchins, 1991). Combining both social and cognitive aspects, DCog suggests that learning should be perceived as a process distributed across individuals and artifacts (Salomon, 1993). Hutchins (1987) also discussed ‘collaborative manipulation’, the process in which we leveraged on artifacts designed by others (and ourselves) to share ideas across time and spaces.

All these core assertions of DCog mesh well with the salient characteristics of seamless learning, such as the bridging of individual and social learning, the learners’ appropriation of elements (artifacts) available in specific learning spaces to support their learning, and the bridging of cross-space learning efforts mediated by specific artifacts (e.g., the mobile device, or student artifacts created in previous activities). Relating to this perspective, a learning context is not necessarily confined within a specific learning space and a specific time frame. Instead, a learning context may span across time and spaces, and constantly reconstructed through switching of learning tasks. Thus, it is not surprising that scholars tapped on DCog when constructing theoretical or methodological frameworks for seamless learning (e.g., Looi et al., 2010; Otero et al., 2011; Wong, Chen, & Jan, 2012).

The third set of MSL literature placed its emphasis on the pedagogical aspect and/or constructivist affinity of seamless learning and made references to knowledge building, knowledge spirals, inquiry learning, sense making or meaning making, learner-generated contexts, learning with patterns, scaffolding, cognitive apprenticeship, and differentiated instructions. Again, in the eyes of MSL researchers, every knowledge construction process should be extended and bridged, rather than being confined within one single learning session.

In addition, not as a learning concept or pedagogical paradigm but a process framework for knowledge management, the SECI model (Nonaka & Takeuchi, 1995) was adopted by three MSL

studies in developing their respective process frameworks or solutions. The SECI model describes the dynamics of knowledge evolution as a knowledge spiral within a knowledge-creating enterprise, with the process of knowledge creation involving four cyclical stages: Socialization, Externalization, Combination and Internalization – which again should be carried out across time and spaces.

A smaller set of studies associated their designs or analyses with the notions of self-guided exploration, self-directed learning, lifelong learning, and transformation of participation – all can be seen as variations of autonomous learning. Indeed, seamless learning itself can be classified along with this group of notions that aim to promote certain self-regulatory and habitual learning cultures.

Through the analysis of the diverse theoretical underpinnings of seamless learning in this section, the sociocultural perspective of learning consistently stands out as the implicit guiding philosophy for the conceptualization, implementation and interpretation of the notion. Constructivism and socio-constructivism become the common threads that weave together individual or groups of learners' learning efforts and experiences across multiple spaces, (perhaps) with the eventual goal of fostering a sustainable sense of learning ownership in them.

4. Conclusion – Bridging the Past and the Future

Looking back the past 7 years, though not a well-modeled or well-theorized learning notion to start with, the 'second life' of seamless learning has continued to show its strong potential and promise, and gradually become a mature line of research and practice. Indeed, it was the 'second life' of the learning notion that has substantially enriched and even re-defined its 'first life'. In this paper, we have attempted to make deeper sense of seamless learning both within and beyond the context of TEL. Through examining the MSL literature, it is further affirmative that seamless learning is much more than a special form of any other learning method. It is indeed a learning approach at its own right and with its own niche – with '*bridging* of cross-space learning efforts' as the defining feature. Indeed, seamless learning is an ever evolving landscape that needs to be constantly refined, re-interpreted and re-contextualized.

References

- American College Personnel Association. (1994). *The student learning imperative: Implications for student affairs*. Washington, D.C.: Author.
- Baloian, N., & Zurita, G. (2012). Ubiquitous mobile knowledge construction in collaborative learning environments. *Sensors*, 12, 6995-7014.
- Barron, B. (2006). Interest and self-sustained learning as catalysts of development: A learningecologies perspective. *Human Development*, 49(4), 193-224.
- Bentley, Y., Shegunshi, A., & Scannell, M. (2010). Evaluating the impact of distance learning support systems on the learning experience of MBA students in a global context. *Electronic Journal of e-Learning*, 8(2), 51-62.
- Bloland, P. A., Stamatakis, L. C., & Rogers, R. R. (1994). Reform in student affairs: A critique of student development *ERIC Counseling&Student Services Clearinghouse*. Durham, NC: University of North Carolina, School of Education.
- Chan, T.-W., Roschelle, J., Hsi, S., Kinshuk, Sharples, M., Brown, T., . . . Hoppe, U. (2006). One-to-one technology-enhanced learning: An opportunity for global research collaboration. *Research and Practice in Technology-Enhanced Learning*, 1(1), 3-29.
- Cheng, Z., Sun, S., Kansan, M., Huang, T., & He, A. (2005). *A personalized ubiquitous education support environment by comparing learning instructional requirement with learner's behavior*. Paper presented at the International Conference on Advanced Information Networking and Applications 2005, Taipei, Taiwan.
- Chiu, P.-S., Kuo, Y.-H., Huang, Y.-M., & Chen, T.-S. (2008). *The ubiquitous learning evaluation method based on meaningful learning*. Paper presented at the International Conference on Computers in Education 2008, Taipei, Taiwan.
- Fang, H., Wang, H., & Huang, R. (2011). *A roadmap of system environment to ubiquitous learning and its application patterns*. Paper presented at the 6th IEEE Joint International Conference on Information Technology and Artificial Intelligence, Beijing, China.
- Flor, N., & Hutchins, E. (1991). *Analyzing distributed cognition in software teams: a case study of team programming during perfective software maintenance*. Paper presented at the Fourth Annual Workshop on Empirical Studies of Programmers, Norwood, NJ.

- Huang, Y.-T., Chung, C.-I., Tsai, C.-C., Shen, C.-H., Wu, Y.-C., & Yang, J.-C. (2007). *A mobile video question answering system for e-learning*. Paper presented at the IEEE International Conference on Advanced Learning Technologies 2007, Niigata, Japan.
- Hutchins, E. (1987). *Metaphors for interface design ICS Report 8703*. La Jolla: University of California, San Diego.
- Hwang, G.-J., Tsai, C.-C., & Yang, S. J. H. (2008). Criteria, strategies and research issues of context-aware ubiquitous learning. *Educational Technology & Society*, 11(2), 81-91.
- Kezar, A. (2003). Enhancing innovative partnerships: Creating a change model for academic and student affairs collaboration. *Innovative Higher Education*, 28(2), 137-156.
- Knefelkamp, L. L. (1991). *The seamless curriculum. CIC Deans Institute: Is this good for our students?* Washington, DC: Council for Independent Colleges.
- Kolb, D. A. (1984). *Experiential learning: experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice Hall.
- Kuh, G. D. (1996). Guiding principles for creating seamless learning environments for undergraduates. *College Student Development*, 37(2), 135-148.
- Kurti, A., Spikol, D., & Milrad, M. (2008). Bridging outdoors and indoors educational activities in schools with the support of mobile and positioning technologies. *International Journal of Mobile Learning and Organisation*, 2(2), 166-186.
- Lai, C.-H., Yang, J.-C., Chen, F.-C., Ho, C.-W., & Chan, T.-W. (2007). Affordances of mobile technologies for experiential learning: the interplay of technology and pedagogical practices. *Journal of Computer Assisted Learning*, 23(4), 326-337.
- Looi, C.-K., Seow, P., Zhang, B. H., So, H.-J., Chen, W., & Wong, L.-H. (2010). Leveraging mobile technology for sustainable seamless learning: A research agenda. *British Journal of Educational Technology*, 42(1), 154-169.
- Looi, C.-K., & Wong, L.-H. (in-press-a). Designing for seamless learning. In R. Luckin, P. Goodyear, B. Grabowski & N. Winters (Eds.), *Handbook of Design in Educational Technology*: Routledge.
- Looi, C.-K., & Wong, L.-H. (in-press-b). Implementing mobile learning curricula in Singapore schools: A Programme of research from innovation to scaling. *Educational Technology & Society*, 17(1).
- Looi, C.-K., Wong, L.-H., So, H.-J., Seow, P., Toh, Y., Chen, W., . . . Soloway, E. (2009). Anatomy of a mobilized lesson: Learning my way. *Computers & Education*, 53(4), 1120-1132.
- Maldonado, H., & Pea, R. (2010). *LET's GO! to the Creek: Co-design of water quality inquiry using mobile science collaboratories*. Paper presented at the IEEE International Conference on Wireless, Mobile, and Ubiquitous Technologies in Education 2010, Kaohsiung, Taiwan.
- Milrad, M., Wong, L.-H., Sharples, M., Hwang, G.-J., Looi, C.-K., & Ogata, H. (2013). Seamless learning: An international perspective on next generation technology enhanced learning. In Z. L. Berge & L. Y. Muilenburg (Eds.), *The Handbook of Mobile Learning* (pp. 95-108). New York: Routledge.
- Miyata, H., Sannomiya, M., & Suzuki, M. (2010). Development and evaluation of web-based mobile contents for logical thinking by teaching students 'how to think'. *International Journal of Mobile Learning and Organisation*, 4(4), 391-406.
- Narayanansamy, M., & Ismail, I. (2011). Introducing Mobile Technology as a Tool for Teaching. *Malaysian Journal of Distance Education*, 13(2), 9-18.
- Ng, W., & Nicholas, H. (2007). *Ubiquitous learning with handhelds in schools*. Paper presented at the International Conference on Mobile Learning 2007, Melbourne, Australia.
- Ng, W., & Nicholas, H. (2009). Introducing pocket PCs in schools: Attitudes and beliefs in the first year. *Computers & Education*, 52, 470-480.
- Nonaka, I., & Takeuchi, H. (1995). *The Knowledge Creating Company*. Oxford: Oxford University Press.
- Obisat, F., & Hattab, E. (2009). A proposed model for individualized learning through mobile technologies. *Computers*, 1(3), 125-132.
- Ogata, H., Hui, G. L., Yin, C., Ueda, T., Oishi, Y., & Yano, Y. (2008). LOCH: Supporting mobile language learning outside classrooms. *Mobile Learning and Organisation*, 2(3), 271-282.
- Otero, N., Milrad, M., Rogers, Y., Santos, A. J., Veríssimo, M., & Torres, N. (2011). Challenges in designing seamless-learning scenarios: affective and emotional effects on external representations. *Mobile Learning and Organisation*, 5(1), 15-27.
- Pea, R. (2009). *Keynote speech: Fostering learning in the networked world: Trends, opportunities and challenges for learning environments and education*. Paper presented at the 3rd Redesigning Pedagogy International Conference, Singapore.
- Pegrum, M., Oakley, G., & Faulkner, R. (2013). Schools going mobile: A study of the adoption of mobile handheld technologies in Western Australian independent schools. *Australasian Journal of Educational Technology*, 29(1), 66-81.
- Rogers, Y., & Price, S. (2008). The role of mobile devices in facilitating collaborative inquiry in situ. *Research and Practice in Technology Enhanced Learning*, 3(3), 209-229.

- Rogers, Y., & Price, S. (2009). How mobile technologies are changing the way children learn. In A. Druin (Ed.), *Mobile Technology for Children* (pp. 3-22). Boston: Morgan Kaufmann.
- Salomon, G. (1993). *Distributed Cognitions: Psychological and Educational Considerations*. Cambridge, UK: Cambridge University Press.
- Sha, L., Looi, C.-K., Chen, W., & Zhang, B. (2012). Understanding mobile learning from the perspective of self-regulated learning. *Journal of Computer Assisted Learning*, 28(4), 366-378.
- Sharples, M., McAndrew, P., Weller, M., Ferguson, R., FitzGerald, E., Hirst, T., . . . Whitelock, D. (2012). *Innovating Pedagogy 2012*. Milton Keynes, UK: The Open University.
- Sharples, M., Taylor, J., & Vavoula, G. (2007). A theory of learning for the mobile age. In R. Andrews & C. Haythornthwaite (Eds.), *The Sage Handbook of E-learning Research* (pp. 221-247). London: Sage.
- Shih, W.-C., & Tseng, S.-S. (2009). A knowledge-based approach to retrieving teaching materials for context-aware learning. *Educational Technology & Society*, 12(1), 82-106.
- Sollervall, H., & Milrad, M. (2012). Theoretical and methodological considerations regarding the design of innovative mathematical learning activities with mobile technologies. *International Journal of Mobile Learning and Organisation*, 6(2), 172-187.
- Song, Y., Wong, L.-H., & Looi, C.-K. (2012). Fostering personalized learning in science inquiry supported by mobile technologies. *Educational Technology Research and Development*, 60(4), 679-701.
- Thomas, S., Schott, G., & Kambouri, M. (2004). Designing for learning or designing for fun? Setting usability guidelines for mobile educational games. In J. Attewell & C. Savill-Smith (Eds.), *Learning with Mobile Devices: Research and Development* (pp. 173-181). London, UK: Learning and Skills Development Agency.
- Tillman, N., Moskal, M., de Halleux, J., Fahndrich, M., Bishop, J., Samuel, A., & Xie, T. (2012). *The future of teaching programming is on mobile devices*. Paper presented at the 17th ACM Annual Conference on Innovation and Technology in Computer Science Education Haifa, Israel.
- Toh, Y., So, H.-J., Seow, P., Chen, W., & Looi, C.-K. (2013). Seamless learning in the mobile age: A theoretical and methodological discussion on using cooperative inquiry to study digital kids on-the-move. *Learning, Media and Technology*, 38(3), 301-318. doi: 10.1080/17439884.2012.666250
- Tsoi, M. Y., & Dekhane, S. (2011). *TsoiChem: A mobile application to facilitate student learning in organic chemistry*. Paper presented at the 11th IEEE International Conference on Advanced Learning Technologies, Athens, GA.
- Vogel, D., Kennedy, D. M., Kuan, K., Kwok, R., & Lai, J. (2007). *Do mobile device applications affect learning?* Paper presented at the Hawaii International Conference on System Sciences 2007, Big Island, Hawaii.
- Wang, W., & Wang, Z. (2008). Leveraging on u-learning to nurture a society of learning. *China Educational Technique & Equipment*, 2008(22), 33-35.
- Whitworth, A. (2008). *Learner generated contexts: critical theory and ICT education*. Paper presented at the Panhellenic Conference on Information and Communication Technologies in Education 2008, Limassol, Cyprus.
- Wong, L.-H. (2012). A learner-centric view of mobile seamless learning. *British Journal of Educational Technology*, 43(1), E19-E23.
- Wong, L.-H. (2013). Analysis of students' after-school mobile-assisted artifact creation processes in a seamless language learning environment. *Educational Technology & Society*, 16(2), 198-211.
- Wong, L.-H. (forthcoming). A brief history of seamless learning. In L.-H. Wong, M. Milrad & M. Specht (Eds.), *Seamless Learning in the Age of Mobile Connectivity*: Springer.
- Wong, L.-H. (in-press). Enculturating self-directed learners through a facilitated seamless learning process framework. *Technology, Pedagogy and Education*. doi: 10.1080/1475939X.2013.778447
- Wong, L.-H., Chen, W., & Jan, M. (2012). How artefacts mediate small group co-creation activities in a mobile-assisted language learning environment? *Journal of Computer Assisted Learning*, 28(5), 411-424.
- Wong, L.-H., Chin, C.-K., Tan, C.-L., & Liu, M. (2010). Students' personal and social meaning making in a Chinese idiom mobile learning environment. *Educational Technology & Society*, 13(4), 15-26.
- Wong, L.-H., & Looi, C.-K. (2011). What seems do we remove in mobile assisted seamless learning? A critical review of the literature. *Computers & Education*, 57(4), 2364-2381. doi: 10.1080/10494820.2012.745424
- Yang, S. J. H. (2006). Context aware ubiquitous learning environments for peer-to-peer collaborative learning. *Educational Technology & Society*, 9(1), 188-201.
- Yu, S., Yang, X., & Cheng, G. (2009). Learning resource design and sharing in ubiquitous learning environment: The concept and architecture of learning cell. *Open Education Research*, 15(1), 47-53.

Mobile Supported Flipped Instruction and Learning

Wan NG

School of Education, University of New South Wales, Australia

*w.ng@unsw.edu.au

Abstract: The discussion of *flipped classroom*, while not an entirely new concept to the field of teaching, has been very active on blog sites on the Web in recent years while its academic literature to date is scant. This paper presents a review of the literature on the concept, discusses mobile-supported flipped classroom teaching and learning, presents an example of a mobile-supported flipped classroom pedagogy and identify benefits, issues and implications of flipped classroom.

Keywords: flipped learning and teaching, mobile technology, pedagogy

1. Introduction

The *Inverted Classroom* is a term first used by Lage, Platt and Treglia in 2000, which was later adopted in other studies (e.g. Talbert, 2011; Strayer, 2012) in the higher education contexts. Synonymous with the inverted classroom is the *Flipped Classroom*, usually referring to contexts within schools. Put simply, the *flipped classroom* learning model reverses the teaching in the classroom with homework that is done outside the classroom (Bergmann & Sams, 2012; Hamdan, McKnight, McKnight & Srfstrom, 2013). The teacher creates videos of him/herself teaching or narrates and records screencasts of work such as explaining and showing derivations of formula in mathematics or illustrations in science and geography on the screen. Alternatively, the teacher may make use of videos that are already freely available on the Internet, for example from YouTube, the Khan Academy or MIT websites. These instructional videos produced by the teacher, referred to as *vodcasts* for the remaining of this article, are uploaded onto a platform such as YouTube or the institute's learning management system (e.g. Blackboard, Moodle, Edmodo) for students to access in their own space and time. This access would be enhanced if students could make use of the mobile devices that they own to retrieve the vodcasts and other resources. The idea is for students to view and listen to the teaching in informal learning settings that is outside the classroom in preparation for the activities that are planned for them in the formal learning setting of the classroom in the next session of the course or subject. The argument for flipping the classroom in this way is to enable the more passive aspect of learning, that is, the absorbing of information conveyed by the teacher to be carried out at home, so that classroom time is reserved for more interactive activities where the teacher could help individual students with their issues and where peers could collaborate on tasks that build on the learning conducted at home.

The concept of inverting, flipping or reversing the classroom is not new. Practitioners on blog sites and discussion forums comment that they have practiced it as a repertoire of their teaching strategies for as long as they have been teachers. This has taken the form of getting students to read sections from their textbooks, try problems or research materials at home in preparation for the next lesson. With the advent of technology and learning management systems (LMS), higher education teachers often release readings and/or Powerpoints on LMS for students to view prior to lectures. With more schools now taking on board learning management systems, similar practices will become more prevalent. As technology evolves to be more user-friendly, teachers are able to video record, audio record and screencast record their teaching and upload them for student access via the institution's learning management system or YouTube prior to class sessions. With the ownerships of smartphones and tablets on the rise (BBC, 2008; Cerwall, 2012; Griffith, 2013; Sherman, 2013; Whitney, 2009) and with BBC online (2008) reporting that mobile net users are getting younger, access to these pre-recorded teaching in students' own space and time are becoming easier and could enhance flipped

classroom learning. The one-to-one computing (Chan et al., 2006) phenomenon where students have access to individual mobile devices (in particular laptops) is already happening in many secondary and tertiary educational institutions. Hence it is appropriate for researchers and teachers to conceptualise flipped classroom instructional and learning practices in light of mobility and ownership of mobile devices and how best to capitalise on them.

The paper will review the literature on flipped or inverted classroom in relation to existing conceptual frameworks and educational impact, discuss mobile – supported flipped classroom teaching and learning, present an example of a mobile-supported flipped classroom pedagogy and conclude by identifying benefits, issues and implications for flipped classroom practices.

2. Reviewing the literature

2.1 Theoretical underpinnings for flipped teaching and learning

Empirical-based evidence of the practice and impact of flipping the classroom in journal- and book-based literature is currently rather limited. However, the discussions of the topic in blog and other online sites (see footnote [1] for some examples of sites) is increasing in frequency. The general theoretical underpinnings for flipped classroom in the literature (e.g. Berrett, 2012; Flumerfelt & Green, 2013; Frydenberg, 2013; Marcey & Brint 2012; Talbert, 2011) and online discussions¹ is the use of videos to shift students' direct and passive learning in lectures in large groups in the classroom to individual learning spaces outside the classroom. In the classroom space, students would focus on and engage in activities that foster deeper understanding and higher order thinking through discussion, practical work and problem-solving tasks that they do individually or collaboratively in small groups. In order to solve problems, the students need to have a mastery of the concepts involved and would draw on the knowledge gained through viewing the videos at home. Individual students have the opportunity to clarify concepts taught in the videos that they are unsure of with the teacher in the classroom. Hence, the teacher takes on the role of a facilitator or mentor, moving around the classroom providing explanations, additional information and help to the students on a needs basis. By being able to pay attention to individual students, the teacher is also able to assess and gauge where each of them is at in the understanding of the content taught. This type of student-centred learning enabled by flipping the classroom is supported by practitioners who reported on student gains (Hamdan et al., 2013).

The flipped learning framework is supported by existing theories of learning - Bruner's (1966) cognitive constructivist learning theory and Vygotsky's (1962) social-constructivist theory. Constructivist theory posits that real learning can only take place when the learner is actively interacting with the learning materials and engaged in the learning process such as viewing and making sense of video content at home and discussing and collaborating with peers in the classroom in the flipped learning context. A difference between cognitive and social constructivism is that in the former, the teacher plays a limited role whereas in the latter, the role of the teacher is active and involved in helping students to grasp concepts by guiding and encouraging engagement in activities such as group work. Also central to Vygotsky's theory is the role of others (for example peers and parents) in mediating the learner's access to new experiences and knowledge. The student-centred feature of flipped learning means that students are actively engaging in their learning, taking responsibility for and having ownership of the learning. This active, personalised approach to learning using technology increases students' engagement and promote better learning outcomes (Michael, 2006; Ng, 2008).

The key features for effective flipped classroom practice have been identified by Pearson & The Flipped Learning Network (2013). These features were described as the four pillars of FLIP: (i) Flexible environment: the informal flipped learning allows for flexible individual learning in one's own space and time. Flipped classrooms allow for a variety of learning modes and may involve group work, independent study, research, performance, and evaluation. In-class time may be somewhat chaotic and noisy compared with the quiet, passive behaviour during a traditional lecture. In addition, flipped

[¹] <http://www.thedailyriff.com/articles/the-flipped-class-conversation-689.php>
<http://flippedlearning.org/FLN>
<http://blendedclassroom.blogspot.com.au/>
<http://www.knewton.com/flipped-classroom/>

instructions also mean flexibility in pace of learning and assessment, designing appropriate assessments systems that objectively measure understanding in a way that is meaningful for students and the teacher. (ii) **Learning culture** - flipped learning requires a shift in learning culture, from teacher-centred to student-centred approaches of instruction where “students move from being the product of teaching to the center of learning, where they are actively involved in knowledge formation through opportunities to participate in and evaluate their learning in a manner that is personally meaningful” (Hamdan et al., 2013, p.5). (iii) **Intentional content** - teachers need to evaluate the content they require their students to explore first in their own time outside the classroom, and the activities to adopt for active learning in the classroom such as peer instruction, peer-review, problem-based learning or individual research and (iv) **Professional educator** - flipped learning requires professional educators. Flipped professional educators are more important and more demanding than traditional educators. They are required to decide on when and how to shift group-based direct instruction to the individual learning space as well as how to maximize the face-to-face interactions between teacher and students. They are required to continually observe their students and assess their work in class, providing them with relevant feedback where appropriate. They take on a less visible role in the flipped classroom, are tolerant of classroom noise and disorder and are reflective practitioners.

2.2 Impact of flipped classroom on learning

As noted in the abstract for this paper, empirical evidence based on rigorous methodology investigating the impact of flipping the classroom is still scarce. There are several studies that show positive impact of the flipped classroom pedagogy on students’ learning. In higher education, Marcey and Brint (2012) investigated the flipped classroom concept with a group of undergraduate biology students through cinematic lectures and inverted class pedagogy. Their results showed that in comparison with a ‘control’ group of traditionally taught students, there were statistically significant differences in learning outcomes with the flipped class students performing better on all the tests and quizzes. Frydenberg (2013) reported on the implementation of the flipped classroom pedagogy in a first year introductory Information Technology course, focusing on how the flipped strategies facilitated students’ experiences learning about Excel concepts. The students’ responses indicated that the flipped instructional methods captured their interests, challenged their thinking and contributed to their learning. In another study, Papadopoulos, Santiago-Román and Portela (2010) developed, implemented and assessed an inverted classroom model for an Engineering Statistic course. Their model consisted of a set of per-lecture modules and exercises online, a lecture that responded to the students’ experiences in the pre-lecture activities and a problem-solving session after each lecture. The survey results showed that there was general endorsement of the inverted class model with 81% of the student group preferring the inverted format over the traditional method of teaching. Test scores revealed that the inverted group performed significantly higher than the control group.

At the school level, case studies reported by Hamdan et al. (2013) showed that in one school, the mathematics teachers found an increase in student engagement that exceeded expectations after flipping their mathematics classroom and that nearly three-quarters (73.8%) of students passed the state mathematics test, which is more than double the performance from just three years earlier. Another case study indicated that failure rates dropped by as much as 33% (Green, 2012) as a result of flipping the classroom. In another study, Flumerfelt and Green (2013) worked with a group of 23 at risk students using the flipped classroom approach and found that the students increased their online engagement and homework rates from 75% to 100%. Students’ successes also increased by 11% in the flipped class compared with the control class.

It is evident from recent publications that interest in the flipped classroom concept is increasing. However, until more research is conducted, in particular on the attitudes, pedagogy and workload of teachers engaging with flipped classroom practices, the impact and uptake of flipping the classroom remains to be seen.

3. Mobile-supported flipped classrooms

Adwell et. al.(2007) noted the two winds of change that will impact on technology and education of the

future as (i) the rapid advancement of technologies themselves and (ii) the changing of physical classrooms to 'learning spaces' where learning spaces could be physical, virtual or a blend of both. The integrated nature of these types of changes support the flipped classroom practice to enable learning that is independent, continuous and seamless. The transformation of 'classrooms' that are flipped into 'learning spaces' that are blended combines the physical space (classrooms, laboratories, home) and virtual space (supported by mobile technologies, learning management systems, Web 2.0 technologies etc) making these learning spaces more flexible and more multidimensional. Formally scheduled learning takes place in physical or virtual learning spaces and less formal learning in social learning spaces where interactions with peers could also be both physical and virtual. A study by Matthews, Andrews & Adams (2011) has shown that students who used social learning spaces demonstrated enhanced engagement with the learning than non-users. These spaces fostered active learning through social interactions, creating a better sense of belonging amongst the students. Mobile devices and apps are enablers of social learning where contact with peers or other experts online to obtain just-in-time assistance, through texting, messenger, email and blog/forum discussion could occur easily. Mobile device features and apps are also enablers of multimodal presentations of content that assist students to learn from a variety of format e.g. podcasts and vodcasts/simulations that are multimedia and visual. In today's society where technology penetrates almost all sectors of life, meaning making is increasingly more multimodal where the written-linguistic modes are integral of visual, audio, gestural and spatial patterns of meaning (New London Group, 1996). An implication of engaging with multimodality is that teachers and students have multiliteracies skills and knowledge, that is, the ability to construct meanings as well as decoding meanings, that is, drawing out meanings and interpreting information from *text* (written descriptions and explanations), *visuals* (images – photos, pictures, drawings, illustrations, graphs), *sound bytes* (e.g. podcasts, narratives, music), *videos* (multimedia: visual, sound etc), *maps* (static e.g. GoogleMap or dynamic e.g. Google Earth) and *conceptual models* (e.g. 3-D models such as DNA or 2-D models in the form of concept maps, diagrams). Multimodal means of representations in flipped learning cater to a wider range of students' ability and interest (New London Group, 1006; Ng, 2012), hence assisting with better learning that students do on their own at home.

3.1 Learning with mobile technology in flipped classroom

An example of how mobile technology could be used in a flipped classroom teaching the interdisciplinary topic of nanotechnology, suitable for years 9 and 10 students, is shown in the Appendix of this paper. The strategies used capture the social and multimodal learning advantages offered by mobile technology discussed above. The activities and content suggested are supportable by mobile devices although there will be more challenges if students are using smartphones of different mobile platforms. A more manageable strategy is the integration of a standard type of tablet (e.g. iPad or Samsung Galaxy Tab) for all students. Like any other teaching, flipped teaching that is supported by mobile technology requires that the teacher has good pedagogical skills. This includes having an understanding of how their students learn and what motivates them, their prior knowledge, the difficulties that they are likely to encounter, the abstractness of the concepts to be delivered and how best to vary teaching methods and activities to cater for the variety of interests and abilities in the class. In this respect, the nanotechnology example is not a rigid lesson guide and requires the teachers' discretion to extend an activity or task over two class periods rather than one, or alleviate the need to delegate homework if it is not necessary to do so.

Besides the social and multimodal affordances offered by mobile devices in supporting flipped learning, the mobile device also enables students to watch their teachers' vodcasts on the go e.g. on the bus or train, provided that the vodcasts have been downloaded to the students' smartphone or tablet via the institution's wireless facilities prior to leaving school. With the vodcasts ready for viewing in the students' mobile device, the probability of them viewing the vodcasts while waiting or travelling is higher. As bring-your-own-devices (BYOD) pedagogy is still in the very early stages of policy support and classroom implementation, a mobile supported flipped classroom would be better implemented in tablets-based schools. Designing mobile-supported flipped learning needs to consider:

- the sentiments of the students and ownership of the types of mobile devices (if it is BYOD); negotiate a plan of action with students in terms of taking responsibility for downloading and viewing the vodcasts in preparation for the next lesson.

- be clear with the students in terms of what the learning outcomes are and those that are achievable with mobile technology. It may be necessary to be flexible in terms of interacting with other tools as well.
- the need to release learning materials in small chunks, hence vodcasts created by teachers should be no longer than 15 minutes where explanations are to the point and in layman language, using examples that draws in experiences and events that students are able to relate to. The recorded teaching should be interesting, supported by images that enhance concept development and possible inclusion of other audio or short (1-2 mins) videos e.g. from YouTube or of other people speaking. Video recording the teacher speaking for 15 minutes in a lecture style is a poor form of flipping the classroom.
- ensure that the vodcasts' file sizes and types are manageable by different mobile platforms. Technical frustration is one way of demolishing motivation to learn. Hence allowing class time to trial out similar resources or apps that students need to use in the topic would be a useful way of preparing students for learning with mobile devices.
- ensure that tasks that students have to undertake are pragmatic e.g. limiting writing on small devices and encourage the use of more visuals
- ensure that teachers and students have the necessary mobile literacy to carry out the activities for the topic and
- understand that flipped learning is already being practiced by teachers to varying degree and that a rigid flipped classroom style of instruction has its constraints and may not be suitable for all topics or disciplines.

4. Conclusion

Even though teachers have been flipping instructions for decades (but without the label), a contributing factor to the increase in current interest in the flipped learning concept is the evolution of technology and the one-to-one affordability of mobile technology. The flipped way of learning is essentially blended learning that is enhanced by mobile technology and which provides continuity between formal-informal learning in a seamless manner (Wong & Looi, 2012). The advantages that flipped learning offer include (i) enabling students to learn independently and at his/her own pace, rewinding instructional videos as often as (s)he desires in order to learn the material (ii) students who have been absent are able to catch up with the online materials prepared and uploaded by their teacher on learning management systems (iii) for the teacher, by spending more individual time with students in the classroom answering questions and providing frequent feedback to the students, the teacher develop both better relationship with the students and better understanding of their difficulties (iv) students are able to maximize class time for individual learning with the teacher and develop better peer relationship through teamwork and problem solving tasks and (v) for school children, parents are able to better understand what their children are learning through the vodcasts and be involved.

On the negative side (i) not all students do their homework which will pose more challenges for the teacher. Neither do all adults or parents support more homework for their children (ii) more technology-based homework means more screen time for the students which could impact on health (iii) the preparation of vodcasts could be time consuming and requires the teacher to have a good understanding of the video recording or screencast software, its editing features and how best to integrate the content into producing the vodcasts and (iv) where not all students have access to technology, teachers will need to ensure that they can access one e.g. a loan to them from the institution's repository of mobile devices.

As policy makers and schools are increasingly focusing on one-to-one access to (mobile) technology, its use to support flipped learning is ideal. However flipped instructions are not for all teachers or for all curriculum topics. There need to be careful planning and flexibility in adopting this strategy of learning in the classroom.

References

- Adwell, J., Copeland, N., Forber-Pratt, A., Gitonga, K., Kleber, K., Koplinski, C., Lawhead, M.J., Martin, R., Mattison, R. & Wilken, K. (2007). *Multiliteracies and education*. Retrieved May 23, 2011 from http://wik.ed.uiuc.edu/index.php/Multiliteracies_and_Education.
- BBC (2008). Mobile internet usage on the rise. Retrieved March 8, 2011 from <http://news.bbc.co.uk/2/hi/technology/7748372.stm>
- Bell, B. S. & Kozlowski, S. W. J. (2009). Toward a theory of learner-centered training design: An integrative framework of active learning [Electronic version]. In S. W. J. Kozlowski & E. Salas (Eds.), *Learning, training, and development in organizations* (pp. 263-300). New York: Routledge.
- Bergmann, J., & Sams, A. (2008). Remixing chemistry class. *Learning and Leading with Technology*, 1, 22-27.
- Bergmann, J., & Sams, A. (2012). Flip your classroom: Reach every student in every class every day. Alexandria, VA:ISTE.
- Berrett, D. (2012). How 'flipping' the classroom can improve the traditional lecture. *The Chronicle of Higher Education*, 12. Retrieved July 23, 2013 from http://moodle.technion.ac.il/file.php/1298/Announce/How_Flipping_the_Classroom_Can_Improve_the_Traditional_Lecture.pdf
- Bruner, J. (1966). *Toward a theory of instruction*. Cambridge, MA: Harvard University Press
- Cerwall, P. (2012). Ericsson mobility report. Retrieved 5 June, 2013 from <http://www.ericsson.com/res/investors/docs/2012/ericsson-mobility-report-analyst-brief-nov2012b-a4.pdf>
- Chan, T.W., Roschelle, J., Hsi, S., Kinshuk, Sharples, M., Brown, T., Patton, C., Cherniavsky, J., Pea, R., Norris, C., Soloway, E., Balacheff, N., Scardamalia, M., Dillenbourg, P., Looi, C.K., Milrad, M. & Hoopes, U. (2006) One-to-one technology-enhanced learning: an opportunity for global research collaboration. *Research and Practice in Technology Enhanced Learning*, 1(1), 3–29.
- Green, G. (2012). *The Flipped Classroom and School Approach: Clintondale High School*. Presentation at the annual Building Learning Communities Education Conference, Boston, MA. Retrieved August 5, 2013 from <http://2012.blcconference.com/documents/flipped-classroom-school-approach.pdf>
- Griffith, C. (2013). Desktop sales nosediving as tablets take off: Gartner. *The Australian* newspaper. Retrieved May 14, 2013 from <http://www.theaustralian.com.au/australian-it/it-business/desktop-sales-nosediving-as-tablets-take-off-gartner/story-e6frganx-1226641477479>
- Hamdan, N., McKnight, P., McKnight, K. & Srfstrom, K. M. (2013). A review of flipped learning. Retrieved July 23, 2013 from http://www.flippedlearning.org/cms/lib07/VA01923112/Centricity/Domain/41/LitReview_Flipped_Learning.pdf
- Frydenberg, M. (2013). Flipping Excel. *Information Systems Education Journal*, 11(1), 63-73.
- Flumerfelt, S., & Green, G. (2013). Using Lean in the Flipped Classroom for At Risk Students. *Educational Technology & Society*, 16 (1), 356–366.
- Lage, M. J., Platt, G. J., & Treglia, M. (2000). Inverting the classroom: A gateway to creating an inclusive learning environment. *The Journal of Economic Education*, 31(1), 30-43.
- Marcey, D. J., & Brint, M. E. (2012). Transforming an undergraduate introductory biology course through cinematic lectures and inverted classes: A preliminary assessment of the clic model of the flipped classroom. In *Biology Education Research Symposium at the meeting of the National Association of Biology Teachers*. Retrieved July 28, 2013 from <https://www.nabt.org/websites/institution/File/docs/Four%20Year%20Section/2012%20Proceedings/Marcey%20&%20Brint.pdf>
- Matthews, K. E., Andrews, V. & Adams, P. (2011). Social learning spaces and student engagement. *Higher Education Research and Development*, 30(2), 105-120
- Michael, J. (2006). Where's the evidence that active learning works? *Advances Physiology Education*, 30, 159–167.
- New London Group. (1996). A pedagogy of multiliteracies: Designing social futures. *Harvard Educational Review*, 66(1), 60-92.
- Ng, W, 2008, 'Self-directed learning with web-based sites: how well do students' perceptions and thinking match with their teachers?', *Teaching Science*, vol. 54, no. 2, pp. 26 – 30.
- Ng, W, 2012, *Empowering scientific literacy through digital literacy and multiliteracies*. New York: Nova Science Publishers.
- Papadopoulos, C., Santiago-Román, A., & Portela, G. (2010). Work in progress—Developing and implementing

- an Inverted Classroom for Engineering Statics. In *Frontiers in Education Conference (FIE), 2010 IEEE* (pp. F3F-1). IEEE.
- Pearson & The Flipped Learning Network (2013). *Flipped Learning Professional Development*. Retrieved August 5, 2013 from <http://www.pearsonschool.com/index.cfm?locator=PS2aNj>
- Sherman, J. (2013). Tablet sales on the rise, to surpass PCs by the end of year. Digital Trends. Retrieve May 9, 2013 from <http://www.digitaltrends.com/mobile/tablet-sales-on-the-rise-to-surpass-pcs-by-end-of-year/>
- Strayer, J. F. (2012). How learning in an inverted classroom influences cooperation, innovation and task orientation. *Learning Environments Research*, 15(2), 171-193.
- Talbert, R. (2012). Inverted classroom. *Colleagues*, 9(1), article 7.
- Vygotsky, L. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.
- Whitney, L. (2009). AdMob: iPhones, Android phones on the rise. Retrieved December 7, 2011 from http://news.cnet.com/8301-1035_3-10366193-94.htm
- Wong, L. H., & Looi, C. K. (2011). What seems do we remove in mobile-assisted seamless learning? A critical review of the literature. *Computers & Education*, 57(4), 2364-2381.
- .

Appendix

An example of mobile-technology supported flipped instruction and learning

Objectives 1: Probe for prior knowledge and **2:** Introduce nanotechnology with an aim to motivate and interest

In class:

Probe: (i) what students know: open class discussions about the meaning of nanotechnology (ii) small group discussions of stimulus statements e.g. from Jones, Falvo, Taylor & Broadwell (2007). Examples include:

- there are currently biological nanomachines that naturally exist in your body
- NASA plans to build a space elevator that would use carbon nanotubes to move materials from Earth to outer space
- self-cleaning toilets are now available, these toilets are made with nanotechnology that keeps the porcelain clean
- through nanotechnology, steaks can be made atom-by-atom such that cows are no longer needed to produce the meat.

Pre-test on ‘Size matters’ on SurveyMonkey, students access and complete on mobile device.

1. How big is a nanometer compared to a meter? List one object that is nanosized, one that is smaller, and one that is larger but still not visible to the naked eye.
 2. Name two properties that can differ for nanosized objects and much larger objects of the same substance. For each property, give a specific example.
 3. Describe two reasons why properties of nanosized objects are sometimes different than those of the same substance at the bulk scale.
 4. What do we mean when we talk about “seeing” at the nanoscale?
 5. Choose one technology for seeing at the nanoscale and briefly explain how it works.
 6. Describe one application (or potential application) of nanoscience and its possible effects on society.
- (source for questions: <http://www.ck12.org/book/NanoSense-Student-Materials/r1/section/1.1/>)

Objective 3: Students to have a sense of the smallness of ‘nano’

Outside class:

Read and conceptualise nanotechnology and its scale at the nanometer level at <http://www.ck12.org/book/NanoSense-Student-Materials/r1/section/1.1/> and/or watch YouTube at <https://www.youtube.com/watch?v=TuljCWV6gLU> or at <https://www.youtube.com/watch?v=xlyTex2TF5g&list=TLiIHfHdEFEqQ>

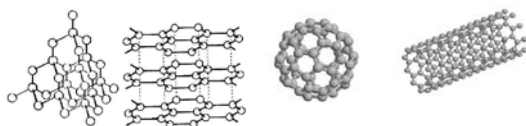
In class:

Students undertake a short online quiz to assess what they have understood about nanotechnology. Define nanotechnology with class. Students start keeping a glossary of terms encountered in the topic in a note-taking app e.g. *EverNote* for smartphone and for tablet (*Pages* for Apple devices, or *Kingsoft Office* for Android devices) Conduct a practical activity that sorts a wide variety of materials into km, m, cm, mm and nm groups to get a sense of dimensions. Students work in small groups to come up with 8 -10 images for each scale and present to class for verification.

Objective 4: Students to understand property changes with size and structure

Outside class:

Revise atoms and molecules: teacher create vodcast for students to view at home. Install *Jmol Molecular Visualization* app for Android devices or *Ball & Stick* app for Apple devices. Explore different structures e.g. water, ethanol, glucose etc Properties change with structure: Find images for the structures of diamond, graphite, bucky ball and nanotube (see below) - these are all made of carbon atoms but are arranged differently and demonstrating different properties, hence different uses. Create a folder for nanotechnology in *Dropbox* and save images.



In class:

Discuss the materials and research on the Web (i) their uses and (ii) how the shape and arrangement of atoms fit the

use.

Construct a table in a word processor - insert images and describe structure and uses

Construct (physically) a paper bucky ball with template at

<http://invention.smithsonian.org/centerpieces/ilives/kroto/buckyball.pdf>

Outside class:

Read about nano particles and sunscreen at

<http://www.cancer.org.au/preventing-cancer/sun-protection/nanoparticles-and-sunscreen.html>

In class:

Properties change with size of materials: Use sunscreen as example. View titanium oxide and zinc oxide on the molecular visualisation apps

Nano-sunscreen experiment: In groups of 2, investigate and compare the differences between zinc cream that stays white when applied with nano-sunscreen which is transparent when applied. Use UV sensitive beads to investigate which materials, e.g. paper, cloth, aluminium foil, students' sunglasses, plastic, cellophane, face foundation etc. will block out UV rays better. Include testing different brands of sunscreen. Video record or take photos of experimental results to be included into report. Write report of the investigation in the mobile devices using a word template that the teacher has created.

Outside class:

View teacher's vodcast on the electromagnetic spectrum

Create a Nanotechnology ePortfolio webpage e.g. on *Wordpress* where students can showcase their work as their learning progresses. Write an Introductory paragraph about nanotechnology; place table and report constructed above on webpage.

In class:

Relate the electromagnetic spectrum and how colours are seen to the nano sunscreen experiment. Learn about UVA, UVB and UVC and why they are harmful.

Students undertake set problems relating to electromagnetic spectrum and undertake an online quiz to reflect on understanding at the end of the period

Objective 5: Students to know about the development of instrumentations (microscopy) in advancing nanotechnology research

Outside class:

View teacher's vodcast on an overview of the evolution of microscopy from magnifying glass to the light microscopy (compound microscope) to the electron microscopy (scanning tunnelling microscope) to the atomic force microscope. The latter 2 enables nanoscale imaging.

In class:

Research further and create a PowerPoint (using *Keynote* for Apple devices or *SoftMaker Presentations Mobile* for Android devices) or Prezi presentation on either the electron or atomic force microscope and its uses.

(Note: Android devices do not support Prezi so students will need to create a PowerPoint or use laptop/desktop to create the Prezi)

Students complete presentation (at home if necessary) and upload his/her presentation to his/her ePortfolio site and sms, email or use messenger (e.g. *WhatsApp*) to send link to two peers for review.

Outside class:

Peers review the presentations on mobile devices and email, sms or send via messenger their comments to the student who created the presentation.

Objective 7: Students to understand about the applications of nanotechnology in their everyday lives

In class and outside class:

Students learn about the applications of nanotechnology by researching artificially synthesised miniature 'things' that could work inside cells e.g. nanobots and useful things outside the body for our day-to-day living e.g. self-cleaning glass; anti-bacterial bench top or food containers; anti-odour and stain resistant clothings, cleaner water, band-aid delivering drugs (hence no injections) and nanodiamonds (4 nm).

Students work in groups of 2 for this task and collaboratively create a glog, video or PowerPoint presentation that will be presented to the class.

Analysis of Ubiquitous Learning Logs in the Context of Science Communications in a Museum

Hiroaki OGATA^{†1}, Kousuke MOURI^{†2}, Mayumi BONO^{†3}, Ayami JOH^{†3}, Katsuya
TAKANASHI^{†4}, Akihiro OSAKI^{†5}, Hiromi OCHIAI^{†5}, Yuko MORITA^{†5}

^{†1} Kyushu University, ^{†2} Tokushima University, ^{†3} National Institute of Informatics, ^{†4} Kyoto University,
^{†5} National Museum of Emerging Science and Innovation
hiroaki.ogata@gmail.com

Abstract: This paper describes how to use a ubiquitous learning log system called SCROLL (System for Capturing and Reusing Of Learning Log) in a museum, especially, in order to support science communicators (SC). Ubiquitous Learning Log (ULL) is defined as a digital record of what you have learned in the daily life using ubiquitous technologies. It allows you to log your learning experiences with photos, audios, videos, location, QR-code, RFID tag, and sensor data, and to share and to reuse ULL with others. Using SCROLL, you can receive personalized quizzes and answers for your questions. This paper describes how to support science communicators in a science museum by using SCROLL, and shows the role of ULL to integrate the quantitative and qualitative analysis.

Keywords: ubiquitous learning log, life log, science museum, science communicator.

1. Introduction

CSUL (Computer Supported Ubiquitous Learning), or context-aware ubiquitous learning (u-Learning) is defined as a technology enhanced learning environment supported by ubiquitous computing technologies such as mobile devices, RFID tags, and wireless sensor networks (Ogata et al, 2004a). CSUL takes place in variety of learning spaces, e.g., classroom, home and museum. Also it provides the right information using the contextual data like location, surrounding objects and temperature.

One of the application domains of CSUL is language learning. For example, TANGO (Ogata et al, 2004b) supports learning vocabularies. The idea of this system is to stick RFID tags to real objects instead of sticky labels, annotate them (e.g., questions and answers), and to share them among others. JAPELAS (Ogata et al, 2004b) aims to support foreigners to learn Japanese polite expressions according to surrounded persons and the place. JAMIOLAS (Ogata et al, 2006) supports learning mimetic words and onomatopoeia using wireless sensor networks. Those researches support learning that happens at anytime and anyplace. However, the other issues emerge how to capture ubiquitous learning experiences and how to reuse them for future learning. Therefore, a ubiquitous learning log system called SCROLL (System for Capturing and Reminding Of Learning Log) (Ogata et al, 2011) has been developed.

Ubiquitous Learning Log (ULL) is defined as a digital record of what learners have learned in the daily life using ubiquitous technologies. It allows the learners to log their learning experiences with photos, audios, videos, location, QR-code, RFID tag, and sensor data, and to share and to reuse ULL with others. Using SCROLL, they can receive personalized quizzes and answers for their questions. Also, they can navigate and be aware of their past ULLs supported by augmented reality view. SCROLL has been used for overseas students learning Japanese, and for Japanese students learning English. Also, seamless learning was conducted using SCROLL in English as the second language course (Uosaki et al, 2012, 2013).

This paper describes how SCROLL can be used in a science museum, Miraikan in Tokyo. There are science communicators in Miraikan so that they can link scientists/engineers with the general

public. When a SC communicates with a visitors, just an explanation of the technology is not good. One of the important skills of SCs is to create mutual communication with visitors and motivate them to know more. However, they have to acquire this skill from the daily experiences because this skill is not shared among SCs. Also, this skill is not easily taken over because the employment term of SCs is 5 years (Bono et al, 2013). Therefore, SCROLL can be applied to capture SCs' skill, share and reuse them for educate SCs.

2. SCROLL: Ubiquitous Learning Log System

2.1 LORE model

Ubiquitous learning log (ULL) is defined as a record of what a learner has learned in the daily life using ubiquitous technologies. ULL is considered as a set of ULLOs. The learning can also be considered as the extraction of meaningful knowledge from past ULL that serves as a guide for future behavior. Figure 1 shows the learning processes in the perspective of the learner's activity model called LORE (Log-Organize-Recall-Evaluate).

- (1) Log what the learner has learned: when the learner faces a problem in the daily life, s/he may learn some knowledge by him/herself, or ask others for a help in terms of questions. The system records what s/he learned during this process as a ULLO.
- (2) Organize ULL: when the learner tries to add a ULLO, the system compares it with other ULLOs, categorizes it and shows the similar ULLOs if exist. By matching similar objects, the knowledge structure can be regulated and organized.
- (3) Reuse ULL: the learner may forget what s/he has learned before. Rehearsal and practice in the same context or in different context in idle moments can help the learner to recall past ULLOs and to shift them from short-term memory to long-term one. Therefore, the system assigns some quizzes and reminds the learner of past ULLOs.
- (4) Evaluate: it is important to recognize what and how the learner has learned by analyzing the past ULL, so that the learner can improve what and how to learn in his future. Therefore, the system refines and adapts the organization of the ULLOs based on the learners' evaluation and reflection.

All the above learning processes can be supported by SCROLL

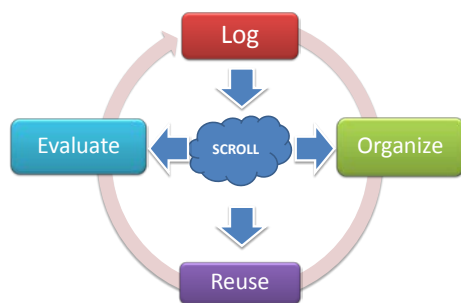


Figure 1: LORE model.



(1) Add ULLO (2) ULLO list (3) Quiz

Figure 2: SCROLL Interface of Android mobile phone.

2.2 System Interface

This section describes the Android user interface of each component.

(1) ULL recorder

This component facilitates an easy way for the learners to upload their ULLOs to the server whenever and wherever they learn. As shown in Figure 2(1), in order to add a ULLO, the learners can take its photo, ask questions about it and attach different kinds of meta-data with it, such as its meanings in different languages (English, Japanese and Chinese), comments, tags and location information. Also the learner can select whether the new ULLO can be shared or not. There are two ways to record ULLO. One is active mode, in which the learner actively take a photo using a smart phone. The other is passive mode using a wearable camera (Hou et al, 2012).

(2) ULL finder

The list of the learner's ULLO is shown in Figure 2(2), which helps him to recall all his past ULL. Besides, it allows him to be aware of the others' learning objects and to re-log them; it means that the learner can make a copy of them into his log. Therefore, the learner can obtain a lot of knowledge from the other learners even though he has not experienced that knowledge by himself. By sharing ULLOs with the other learners and re-logging the other learners' ULLOs, the acquisition of the knowledge is enhanced. As shown in figure 2(3), the system generates simple multiple-choice quizzes based on the meta-data of the stored ULLOs. For example, the idea of "quiz with image" is to ask the learner to choose a word to describe the image given by the system. The system immediately checks whether his answer is correct or not. These quizzes are generated according to his profile, location, time and the results of past quizzes and help the learners to recall what they have learned (Li et al, in press).

The quiz function is designed not only to help the learners to practice what they have learned, but also to recommend what the other learners have learned and to remind them to re-learn their past knowledge according to their current location and their preferred time. In order to achieve these targets, the learner can practice with the quizzes whenever they want. In addition, the client can send the learners' location information to the server all the time. Therefore, the sever side can automatically assign quizzes for the learner based on the location and time information. It notifies the learner to check the quiz by showing an alert message and vibrating the mobile phone. Whenever the learner moves around an area where he has experienced some objects, the system will send him quizzes regarding that objects. Furthermore, the learner can set a time schedule to receive the reminder quizzes.

(3) ULL Navigator

ULL navigator provides mobile augmented reality that allows the learner to navigate through the ULLOs (Mouri et al, 2013). Like Wikitude [www.wikitude.org] and Sekai-Camera [sekaicamera.com], it provides the learner with a live direct view of the physical real-world environment augmented by a real time contextual awareness of the surrounding objects. While a learner is moving with his mobile phone, the system sends an alert on the phone as soon as entering the region of ULLOs according to the GPS data. This view is augmented, associated with a visual compass, and overlapped by the nearest objects in the four cardinal directions (figure 3, left). Also, it provides the learners with a list of all surrounding objects. When the learner selects one or more of these objects, the Google map will be retrieved, and marked with the learner's current location and the selected objects. Moreover, the system shows a path (route) for the learner to reach to the objects locations (figure 3, right). This assists the learner to acquire new knowledge by discovering the existed ULLOs and to recall his ULLOs. In order to reduce the power consuming of the phone battery, the light-mode (blank screen) is developed. In this mode, the phone camera is turned off, and the system displays only information about the surrounding objects. Moreover, by touching the phone screen, a menu will be displayed; it provides the learners with additional facilities, such as displaying a list of all surrounding objects and photos capturing (Camera-mode).



Figure 3. SC's memo (left), SC and visitors (middle), SC inputting data into SCROLL (right).

3. A case study in Miraikan

3.1 Miraikan and Science Communicator

Miraikan is the National Museum of Emerging Science and Innovation in Tokyo, which is a new type of science museum that links people directly with the new wisdom of the 21st century. At the heart of Miraikan's activities is cutting-edge science and technology. This is state-of-the-art knowledge and innovation, which Miraikan aims to share with the whole of society as part of an enriched human culture.

The role of science communicators in Miraikan is to link scientists/engineers with the general public. They create mutual communication between science and society through activities such as providing demonstrations and explanations on the exhibition floors, planning or producing media, events and exhibits as they investigate the trends behind cutting-edge science and technology research. Miraikan also conducts training programs for external personnel working as science communicators, in order to promote interactive communication between citizens, and scientists and engineers. There are about 50 SCs in Miraikan, who have a variety of background such as engineer, news reporter, and medical staff.

When a SC communicates with a visitors, just an explanation of the technology is not good. One of the important skills of SCs is to create mutual communication with visitors and motivate them to know more. However, they acquire this skill from the daily experiences because there is no handbook for acquire this skill. Also, this skill is not easily taken over because the employment term of SCs is 5 years. Therefore, SCROLL can be applied to capture SCs' skill, share and reuse them for educate SCs.

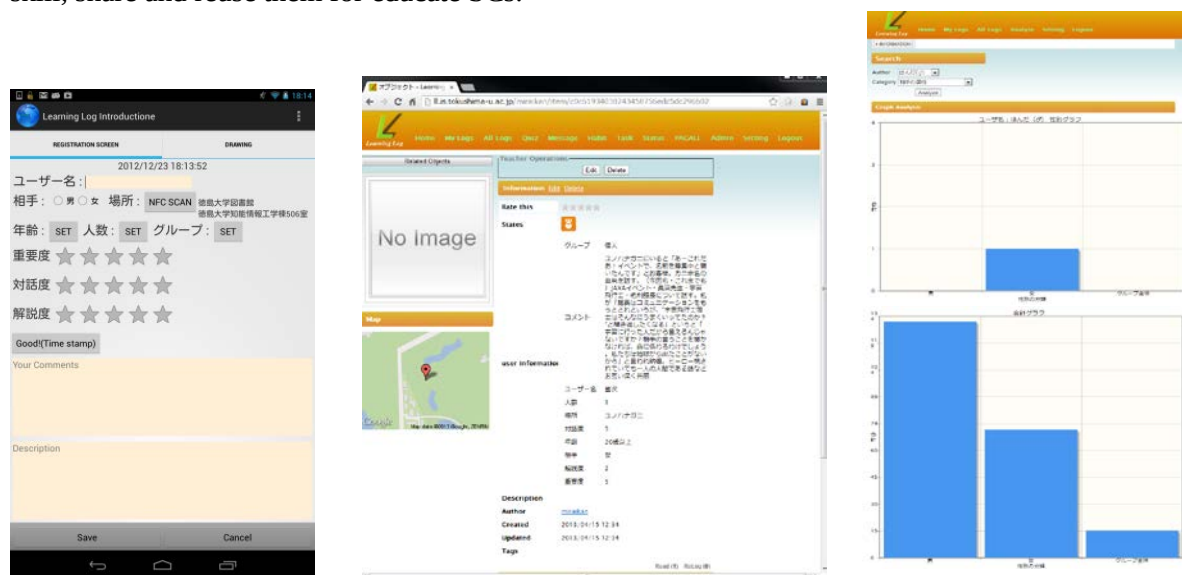


Figure 4. Android interface (left), Web interface (middle), analysis interface (right).

3.2 SCROLL interface

Figure 3 (left) shows SC's memo, which includes visitor's information such as date, place, gender, and the number of the group. Also it includes how to start the communication, and what was told with the visitors. These information is crucial to remind the context of the communication. We apply these items for the data using mobile devices. In addition, the level of interactivity and the level of explanation are added. The higher the level of interactivity is, the better the interaction is. Using a mobile tablet or smartphone, SC inputs data as shown in figure 3 (right). SCs also can share the data as shown in figure 4 (middle) using SCROLL and analyze them as shown in figure 4 (right) by selecting an attribute of data such as the level of interactivity.

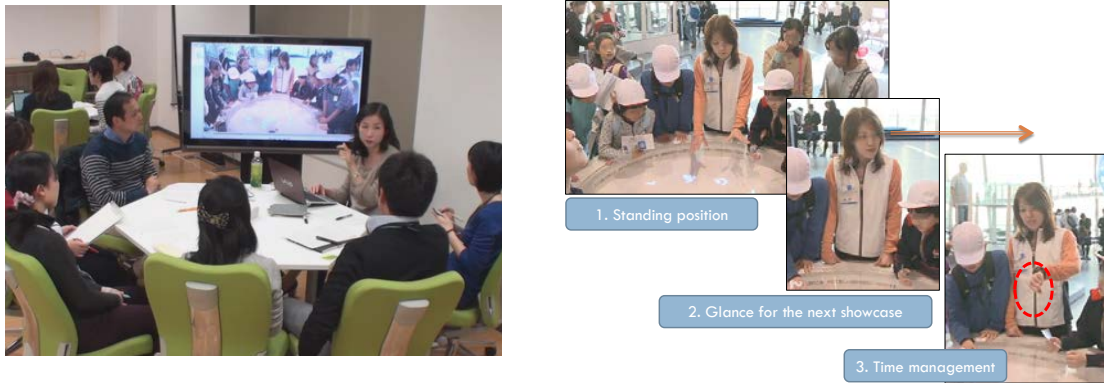


Figure 5. Reflection meeting (left) and results of interaction analysis.

3.3 Reflection meeting

The interactions between a SC and visitors are recorded into video. In reflection meeting, SCs discuss about the video with interaction analysts (IA) and engineers. Also the learning logs stored in SCROLL are referred in the reflection session at the same time. The IAs create the interaction scripts from the video in order to analyze the contents of the video, and find important interactions and gestures. For example, IA pointed out that the standing point of the SC, check the availability of the next showcase, and management of time of visitors are very important at the beginning of the interaction with visitors. Especially, the beginning of interaction are highly significant to attract visitors and to make them want to know more. Therefore, the reflection meeting is essential to integrate the results from quantitative analysis using SCROLL and the results of qualitative (micro and content) analysis.

4. Conclusion and Future Works

This paper describes a learning log system called SCROLL. This paper also proposes how to support science communicators in a science museum by using SCROLL, and shows the role of ULL to integrate the quantitative and qualitative analysis. In the future works, we will conduct a long time evaluation in Miraikan in Tokyo and create a guideline for SCs.

Acknowledgements

This research work was supported by JST PRESTO, and the JSPS Grant-in-Aid for Scientific Research No. 25282059, 25540091 and 21650225 from the Ministry of Education, Science, Sports, and Culture in Japan.

References

- Bono, M., Ogata, H. et al. (2013). Science Communicators as Knowledge Interface, IPSJ SGI HCI, 2013-HCI-151-22.
- Hou, B., Ogata, H., Hou, B., Li, M., and Uosaki, N. (2013). PACALL: Supporting Language Learning Using SenseCam, International Journal of Distance Education Technologies, Vol.11, No.1, pp.14-30.
- Li, M., Ogata, H., Hou, B., and Uosaki, N. (in press). Context-aware and Personalization Method in Ubiquitous Learning Log System, Journal of Educational Technology & Society.
- Mouri, K., Ogata, H., Li, M., Hou, B., and Uosaki, N. (2012). Learning Log Navigator: Augmented Awareness Past Learning Experiences Proc. of IIAI International Conference on Advanced Applied Informatics (IIAI AAI 2012), pp. 159-162.
- Ogata, H., & Yano, Y. (2004a). Context-aware support for computer-supported ubiquitous learning. *Proc. of IEEE International Workshop on Wireless and Mobile Technologies in Education*, 27-34.
- Ogata, H., & Yano, Y. (2004b). Knowledge awareness map for computer-supported ubiquitous language-learning. *Proc. of IEEE International Workshop on Wireless and Mobile Technologies in Education*, 19-26.

- Ogata, H., Yin, C., & Yano, Y. (2006). JAMIOLAS: Supporting Japanese mimicry and onomatopoeia learning with sensors.. *Proc. of IEEE International Workshop on Wireless, Mobile and Ubiquitous Technology in Education, WMUTE'06*, 111–115.
- Ogata, H. et al. (2011). SCROLL: Supporting to Share and Reuse Ubiquitous Learning Log in the Context of Language Learning, *RPTEL*, Vol.6, No.2, pp.69-82.
- Uosaki, N., Ogata, H. Sugimoto, T., Li, M., and Hou, B. (2012). Towards Seamless Vocabulary Learning: How We Can Entwine In-class and Outside-of-class Learning, *International Journal of Mobile Learning and Organization*, Vol.6, No.2, pp.138–155.
- Uosaki, N., Ogata, H., Li, M., Hou, B. and Mouri, K. (2013). Guidelines on Implementing Successful Seamless Learning Environments: a Practitioners' Perspective, *International Journal of Interactive Mobile Technologies*, Vol.7, No.2, pp.44-53.

Developing a Professional Development Model for Science Teachers to Implement a Mobilized Science Curriculum

Daner SUN^{a*}, Chee-Kit LOOI^b, Yen Lin Jenny LEE^c, Jessy Pui Shiong NG^d

^a*Translation and Development Unit, National Institute of Education, Singapore*

^b*Office of Education Research, National Institute of Education, Singapore*

^{c,d}*Science Department, Nan Chiau Primary School, Singapore*

*daner.sun@nie.edu.sg

Abstract: In our work on scaling a mobile technology-facilitated science curriculum called Mobilized 5E Science Curriculum (M5ESC) in a Singapore primary school, great efforts have been devoted to developing a teacher professional development (TPD) model of this curriculum innovation to facilitate teacher enactment of M5ESC in primary schools. In the study, we present the process of professional development for M5ESC and propose a continuing stage-based TPD model for promoting teacher changes on the implementation of M5ESC. Data analysis on a leading teacher's performance and students' work suggested that teacher's pedagogical belief has been transformed into the constructivist orientation influenced by the long term participation of TPD for M5ESC. This is evidenced by her patterns of interacting with students, her use of technology, and her students' active involvement in the student-centered activities.

Keywords: Mobilized 5E Science Curriculum, Teacher Professional Development, Constructivist Orientation

1. Introduction

As a curriculum innovation, the Mobilized 5E Science Curriculum (M5ESC) has been researched and implemented in a Singapore primary school over a period spanning five years. The implementation of this mobile technology-facilitated science curriculum at the school brought about significant changes for both teachers and students. With the intention of scaling M5ESC to other schools, various efforts have been devoted to developing appropriate teaching materials, student work sheets, assessment instruments and a teacher professional development (TPD) model. Among these efforts, TPD was most focused, which was the key component for scaling the M5ESC. Based on literature review, there are limited studies conducted using fine-grained analysis of teachers' practices to understand the affordances of the TPD communities for teachers' changes and limited evidence suggested that teachers who participated in a community experienced positive changes in their attitudes and practices with technology. This paper details teacher changes as part of an effort of a long-term, school-based and continuing TPD community, namely, PD for M5ESC. The study firstly describes the features of the M5ESC, and then presents the principles of effective TPD and the introduction of how the TPD community runs. One leading teacher's class was selected and analyzed to collect evidence for the impact of TPD on teacher performance and student achievement. The findings help to inform the development and research of TPD for implementing mobile technology-facilitated curriculum.

2. Mobilized 5E Science Curriculum

As an innovative science curriculum, M5ESC was developed and elaborated progressively through a design-based research approach. In M5ESC, the lesson design is based on the 5E (Engagement-Exploration- Explanation- Elaboration- Evaluation) instructional model and integrated with the use of various mobile applications (i.e. MyDesk system) (Bybee, 2002). MyDesk supports teachers in creating complete, coordinated, curriculum-based lessons that employ multiple media and applications (e.g. text, graphical, spreadsheet, concept map, animations, and the like). It facilitates them

for evaluating students' artifacts through rating their quality levels and providing immediate feedback. Uniquely, the MyDesk system includes the following applications: KWL (self-reflection), NotePad (taking notes), Recorder (recording voice), Sketchbook (drawing), MapIT (concept map tool), Blurb (question setup tool) which aim to cultivate students' sophisticated and systematic understanding of scientific concepts and develop their modeling skills, reasoning skills and reflective thinking skills in various learning context, especially for them to foster self-directed learning skills in the activities beyond classroom (Greca, & Moreira, 2000; Lim, Lee, & Grabowski, 2009; Brooks, 2009). Other supporting tools are combined with the use of mentioned applications for facilitating various learning, such as built-in camera for taking photos of fieldtrip and experiment, mobile blog and forum for online artifacts sharing and discussion, and search engine for collecting information from other resources. In sum, mobile technology opens the door for a new kind of learning supporting learning anytime and anywhere that occurs when learners have access to information to perform authentic activities in the context of their learning (Martin & Ertzberger, 2013). This facilitates students' science inquiry in "seamless" learning environments, namely, a continuity of the learning experience across different scenarios or contexts (Looi, 2010). Hence, the use of mobile technology particularly supports students' investigation beyond the classroom for observing, recording and collecting data on scientific phenomena in the nature, as well as helps teachers trace and evaluate the learning process out of class.

3. Professional Development Model for M5ESC

Based on literature review, the optimal features of TPD can be built on with following key ideas: First, it should recognize that the reciprocal relationship between TPD and accountability in that the teachers must give consent to what they are being asked to do and the strategies for doing it (Elmore, 2002). Thus, TPD is not a stable and short term working session; it is an interactive and recursive continuum with complex reaction among multiple factors. Second, it must take into account differing needs of different teachers (Stein et al., 1999), and create opportunity for teachers to expose their deficiency, sharing their challenges and learn from each other to peruse the common solutions to the problems and forge consensus about the actions they might take for improvement. Therefore, a learning community is proposed to enable various collaborative activities, particularly those focusing on curriculum and instruction (e.g. lesson plan, teaching strategies, students' achievement, and assessment) (Scribner, Cockrell, Cockrell, & Valentine, 1999), which involves critical, reflective and negotiate dialogue on the disagreement or challenges. Finally, the stage-based model of TPD with situated learning in teacher needs is advocated. The study of most effective TPD models has indicated that the stage by stage with different emphasis and forms of activities facilitates teachers in developing competencies. Teacher growth is closely aligned with their involvement of stage-based TPD. Thus, following the principles of optimal features of effective TPD model, a TPD model was proposed and gradually developed with the progress of M5ESC implementation and scaling within 3-year period. The development stages of TPD for M5ESC are described as Figure 1.

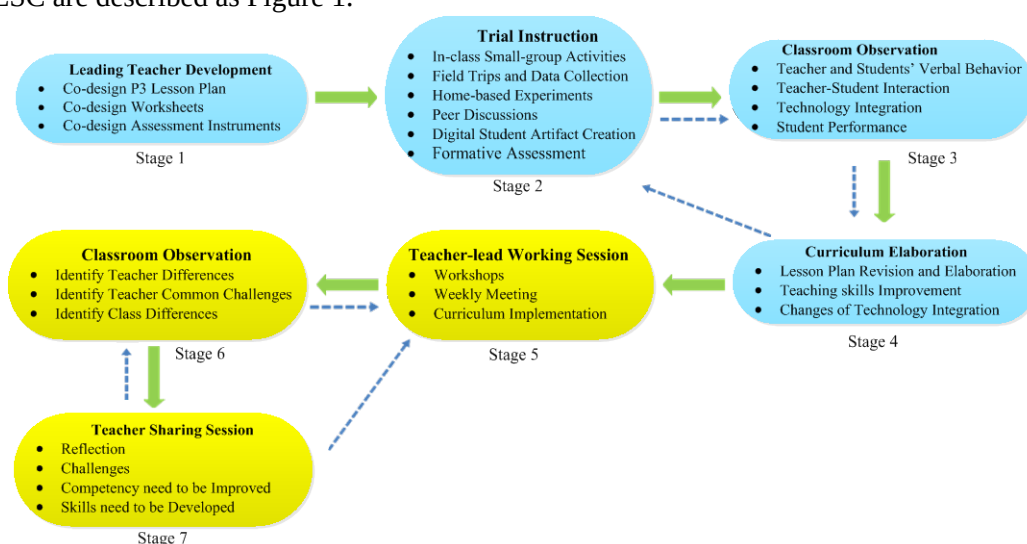


Figure 1. Teacher Professional Development Model for M5ESC

Our model advocates the evolution of TPD as closely related to teachers' instructional practices, the collaboration between researchers and teachers on curriculum development and elaboration, and teachers actively and centrally involved in decisions (Day, 1999). The TPD was built to be a continuous flow of different parties' engagement occurring in two phases: phase I-trial implementation phase (From stage 1 to 4) and phase II-scaling phase (From stage 5 to 7). The phase I is intended to develop the mobilized 5E lesson exemplars and prepare for the consequent PD phase. The phase II emphasizes the development of teachers' competency of M5ESC instruction and the transformation of their pedagogical belief on technology-facilitated curriculum towards constructivist (Ballone & Czerniak, 2001).

At stage 1, one leading teacher Jodie (head of science project with six-year teaching experience) was selected to co-design the curriculum materials with researchers. She has strong willingness to join the project and expects teacher change with participation of long-term TPD. After completing designing each topic (six topics at P3 level were designed), trial instructions of these topics were conducted by Jodie. Two researchers stood by and observed teacher performance in the classroom with focusing on teacher and students' verbal behavior, the patterns of teacher-student interaction, the organization of student activities, the way of technology integration and students' responses and performance, which had been frequently discussed as the major indicators of teacher change (An & Reigeluth, 2012). Data analysis on the above aspects was followed by the classroom observation. The evidence was also collected for detecting the inconsistency between actual teacher performance and expected performance in the lesson design, exposing gaps in the instruction and running of the activities. The results were used to inform curriculum elaboration at stage 4. Meanwhile, immediate feedback and comments of the improvement on both curriculum and instruction were provided to improve the lesson design and subsequent enactments when the teacher finished lessons at one class.

Because of positive outcomes of the pilot run of the M5ESC, the school principal decided to scale up the implementation from one class to all 8 classes of Primary (Grade) 3 in 2012. Besides Jodie, the other 5 teachers were new to the mobilized curriculum. A teaching assistant (called an Allied Educator) was employed to support each teacher in the technology and activity aspects (e.g. mobile applications, experiments, videos, and handheld technology) in the classroom. As the curriculum was to be scaled to all classes in the level and by teachers new to this curriculum, a committee (stage 5: teacher-lead working session) comprising the new teachers, Jodie and the subject head Sharon, ICT head and curriculum planner, researchers and programmers was formed to meet on a weekly basis (McDougall & Squires, 1997). We found this factor to be influential in establishing ownership that positively influenced the teachers' approach to curriculum development and their level of engagement. As a leading teacher of the committee, Jodie provided valuable information on the instruction of M5ESC, the principles of organization of learning activities and the patterns of proposed constructivist practices of technology integration. In the working sessions, they met weekly at a set-aside time to review, revise the lesson plan, discuss and seek consensus on the proposed teaching strategies of the specific content for the forthcoming science lessons and adapt it to fit into the classes of different abilities and cultures which the teacher of each class was familiar with. In particular, they put efforts on discussing how the curriculum might be customized for different ability students and yet at the same time retained the design intent of the curriculum. Additionally, workshops targeting at developing teachers' pedagogical knowledge of 5E and skills of technology use were conducted for supporting new teachers' better alignment of their lesson enactment. Researchers made numerous visits to classrooms during implementation to support teachers and make observations on implementation success and fidelity (e.g. detecting the problems and identifying the challenges and their differences on the enactment). Moreover, some novice teachers' classes were selectively observed by experienced teachers together with researchers. Following by the classroom observation, teacher sharing sessions were regularly conducted for discussing the problems detected and the possible improvement on the competency and skills according to teachers' reflections and researchers' observation and feedback. Especially, critical pedagogical reflection about teaching and learning which has to be seen as an integral part of the teachers' professional development emphasized in our TPD. In TPD, teachers negotiated the possible solutions to the problems between the traditional assessment and the formative assessment of M5ESC. Thus, as a PD community, our TPD is built on the principles of optimal features of TPD model which accommodates the active and frequent interaction between researchers' feedback, teachers' practices and students' responses. Through participating in the TPD, teacher change and

growth are assumed to reach with the long-term iterative lesson enactment, student achievement and performance will arrive at higher levels after being engaging in student-centered activities frequently.

4. Purposes and Research Questions

Building on an understanding of the underlying pedagogy of M5ESC, practice of the M5ESC in the classroom, and participation in the continuing TPD community, the teacher practices in science education move toward more participatory and constructivist-oriented approaches (Nelson, 2009). Thus, the fundamental changes evolving from an emphasis on teacher-centered instruction to student-centered learning is proposed to be observed in the classroom. Therefore, the following research questions were addressed to identify the influence of TPD on teacher enactment of M5ESC.

- How did the TPD for M5ESC change a teacher over time?
- What were the changes of the teacher's pedagogical orientations on the instruction of M5ESC?

5. Methods

5.1 Teacher profile

In the study, we selected the leading teacher Jodie as the target teacher for data analysis. The selection depended on the below justification: a. the teacher should have rich teaching experience, this guaranteed she had adequate content knowledge and common teaching skills of instructional event (e.g. students activities, experiments, demonstration) and class management skills; b. The results of relevant studies showed expert teachers had sets of personal theories and beliefs about classroom practices arising from past experience that were deeply rooted and resistive to change (Wilson, Miller & Yerkes, 1993), they performed difficulty in changing their traditional pedagogical beliefs although they had espoused beliefs, such as constructivist belief. From observing changes of the expert teacher, the evidence might be more persuasive. As a leading teacher, she had joined the project since 2009. She was teaching one higher ability class (n=44). She had strong willingness on teacher changes through long-term TPD, she expected that instruction transformation would take place with active involvement of TPD over time.

5.2 Data Collection and Data Analysis

Both naturalistic and qualitative data were used to gain a holistic vision of curricular implementation by the teacher. At least one researcher attended each class during the use of the curriculum and conducted classroom observation. The researcher also set up a video-recorder at the back of the class to record the class proceedings, and took a mobile video camera to capture group performance and teacher-student interactions. Each group work was audio recorded. The data collection was focused on how the teacher enacted lessons related to key instructional events (e.g. questions, hand-on activities, and experiments) and in particular, how the teacher facilitated the class activities following students' work on the smartphones. Thus, during observations, the researchers focused more on the teacher and student interactions, the teachers' responses to students' questions or answers, as well as the ways in which the use of the mobile technologies was integrated in the class. The researcher wrote field notes to record the lesson sequences, and the major teacher and student behaviors in the instructional events. The lessons of "Exploring Materials" were selected as the target topic for the data analysis (Table 1).

Table 1. The general information of the lesson implemented

5E Stage	Class Activity	Home Activities
Explore	Students design and conduct fair experiments to test properties of materials. Students to observe and compare experiments designed by peers.	Students relate their understanding learned from classroom with their experience out of classroom.

1. Design Experiment • Teacher revisits definitions of strength and hardness on the flipchart and students' responses on KWL. • Teacher invites students to define flexibility and ability to float as characteristics of materials. • Teacher asks the students to design experiments to test for hardness, strength, flexibility and ability to float in different materials.	1. Identify the materials • Students take pictures of materials used in their daily lives using smart phone.
2. Conduct experiment and collect data • Teacher asks the students to conduct experiments they designed. • Students record the experiments using smart phone. • Students take notes of the experiments using smartphone.	2. Relate the properties and their value of the materials • Students describe the purpose of the identified objects and explain the properties of the materials used to suit the purpose through Sketchbook.
3. Share data • Students share findings from experiment via blog and forum.	3. KWL reflection • Students update the KWL to reflect their learning, especially on their thoughts on fairness of experiment.

We analyse the teacher enactment of the lessons using the dimensions of general performance with her pedagogical orientations, the ways she used technology in classroom (Ottenbreit-Leftwich et al., 2012) and the patterns of interaction with the students. Her pedagogical orientation was examined through analyzing her classroom management, instruction of key concepts and her responses to students' questions and activities. Teacher and students verbal behavior were mainly analyzed and compared (King, 1999). The ways in which she integrated the technology in her lessons were discussed and assessed to evaluate her competencies on the use of mobile technology in the class. The data analysis was proposed to further reveal teachers' pedagogical orientations toward the traditional belief (more teacher-guided activities) or constructivist belief (more student-centered activities) on the mobile technology in their lessons (An & Reigeluth, 2012). To visualize the details of teacher enactment of lessons in real class, we also explored her performance on mediating learning by counting the frequency of the exploratory questions and the scaffolds (e.g. scripts, prompts and challenging students' ideas) in the selected lesson episode (Gillies, 2006; Ge & Land, 2004), and by examining the contents and recipients of these questions and scaffolds, this intended to present her patterns of interacting with their students (Chiu, 2004). To verify the student achievement, their learning artifacts in MyDesk were presented and analyzed. The two researchers examined the data individually and then collaboratively in order to reach consensus regarding the identification and description of the teacher's pedagogical orientations and her detailed performance in the teaching practices, as well as students' quality of learning artifacts. The research team helped to check any discrepancies, and made the final decision for the alignment of the coding. Thus, there was no disagreement in the following description and discussion of findings.

6. Findings

6.1 Pedagogical Orientation

Teacher's belief was identified as the most important influence on what they practice in the classroom (Carlson, 1994). The analysis of teacher pedagogical orientation provides a window into teachers'

personal beliefs that influence the enactment of M5ESC and the impact of this on the students' responses. As a leading teacher, Jodie was most familiar with the curricular innovation and understood the underlying principles of the M5ESC. More constructivist teaching strategies were identified in her class compared to her previous class. In M5ESC, before she conducted a collaborative activity, she tended to pose leading questions and expected to students' answers or questions. Then she followed up on questions posed by the students in her class and sought to construct knowledge with the class from these questions instead of providing students with correct answers. Students had more opportunities to discuss with Jodie and their partners in the collaborative activities as Jodie involved frequently in students' peer discussion. For students' experiment, she frequently interacted with students and provided students with scaffolds they required. She focused more on detecting knowledge understanding than reviewing learning artifacts. She acted as a participant and mediator and not a leader in the class inquiry. In exploring the meaning of what students said, she took a genuine interest in students' interpretation of science terms and challenging their ideas through asking questions. In addition, she did not enforce a planned lesson, and would follow the students' learning pace and needs. Thus, Jodie could be identified a teacher who understood to use constructivist strategies (e.g. using students' ideas, providing scaffolds, challenging ideas, and conducting group discussions) to guide and assist students' learning and inquiry, and focused more on developing crucial learning skills instead of emphasizing on remembering and understanding the subject knowledge (Wildy & Wallace, 1995).

6.2 Technology Integration

Table 2 presents the strategies in which Jodie used the technology or technology-related learning artifacts in the instruction of materials in the mobilized 5E science curriculum. We discriminated the ways she used technology as either teacher-guided strategies (Bielefeldt, 2012) or student-centered strategies (Kerawalla, Petrou, & Scanlon, 2013). As we can see in Table 2, more student-centered strategies of technology integration were conducted in Jodie's class, this further reflected her pedagogical orientation on the use of technology in the class. The findings were aligned with the analysis of the pedagogical orientations discussed in the previous section.

Table 2. The ways of the technology integration into the class

Ways of the use of technology	Teacher-guided	Student-centered
• Monitoring the progress	√	
• Evaluation tool	√	
• Identifying misconceptions	√	
• Conducting collaborative work		√
• Guiding students' discussion and thinking		√
• Reflection tool		√
• Comparison tool		√
• Supporting collaborative work		√

In the class of "Exploring Materials", Jodie looked through students' KWL responses and presented the typical work in different quality levels with asking series of questions. She used Socrative.Com (a mobile software supporting presenting multi-choice questions, and reviewing students' responses) to address students' problems in their KWL, and asked students to work in pairs to share their thoughts with other groups (e.g. the meaning of properties with some examples) through Socrative.Com. When students were working together, she was involved in several groups for providing scaffolds on knowledge and guiding them to participate in evaluation and discussion. She observed that students posted wood and metal as examples of properties and addressed students' understanding of properties. She asked students the importance for them to know the properties of materials and asked the students to post why they must know and learn about properties of materials in the KWL. After these activities, most of students revised and elaborated their reflections on the KWL. In the end of the lessons, Jodie returned to the KWL responses which she chose at the beginning of lessons for presenting students' changes on the conceptual understanding of materials. In addition,

when she conducted students' collaborative activities, she reminded students to use video taking tool to record their process and important findings when their partners were doing the activities. Hence, Jodie provided more opportunities for students' inquiry and collaboration with the design of more students-centered activities. Students could use smartphones in the activities more freely and flexibly than other classes.

6.3 Teacher-Student Interaction

Mediated-learning was a way of interaction between the teacher and students. In the study, we identified the scaffolds provided for the students as the methods to mediate the learning, such as scripts, prompts, exploratory questions and challenging student ideas (Weinberger & Fisher, 2006). In Jodie's class, she provided various scaffolds for students and was frequently involved in students' activities in her class. Specifically, Jodie was involved frequently in students' work and tended to provide appropriate scripts and prompts for the students to find the solutions by themselves. Thus, a series of questions were posed in her classes for investigating students' knowledge and identifying misconceptions. There were different levels of interactions existed Jodie's class: teacher-class level: 60 and teacher-student level: 52. As we observed, when she would introduce or explain the key concepts of the materials, she posed a series of exploratory questions (n=37) for guiding students to attain the knowledge (lectures: 10, hands-on experiment: 5, KWL evaluation: 11, and demonstration: 11). A considerable number (16) of the questions were targeted at individual students for identifying their misconceptions or probing their current understanding. The findings reflected that Jodie was skillful at designing and implementing the exploratory questions, and she preferred to listen to her students and provide them with new knowledge based on their prior knowledge. See the following excerpts:

Jodie: Are you trying to say it is not flexible? if it is not flexible ,what will be used?

Jodie: Why don't you use metal, is there is something special about wood?

Jodie: Why do people choose the glass, even it is broken easily. Is that because is harder?

It was found that Jodie provided various scripts for scaffolding students' hands-on experiment (n=14) and demonstration (n=9). These helped the students to construct higher quality work. See some excerpts below:

Jodie: Each of you tests two properties of materials. When you partner do the experiment, you record the experiment. You use video to record your partner's work.

Jodie: How is the plastic? What is flexible? How to test the plastic? Pass the materials to your partners. Remember to use video camera to record the work.

Jodie divided the experiment of testing four properties of materials (e.g. hardness, for hardness, strength, flexibility and ability to float) into four small hands-on activities, each with scripts (14) and instructions. This was specially benefited for the low ability students' completing the task. When students were doing their activities, Jodie mostly detected their problems and was involved in their discussion with providing prompts (4) and challenging their ideas (6). Most students were engaged in their activities and acted the appropriate role in the task. Thus, Jodie could successfully act as a guide, facilitator and mentor in students' activities, which led to students' active participation in hands-on activities and other learning activities.

6.4 Student learning artifacts

Guided by the teacher's instruction, an analysis of the learning artifacts created by students indicated that students benefited a lot in conceptual understanding from M5ESC. Based on the analysis of students' learning artifacts in MyDesk, we found that students performed actively in MapIT, KWL and Skecthbook activities. Take "Exploring Materials" as example, students were required to construct concept maps of material classification using MapIT at first. It was found that most concept maps could present the correct understanding of materials classification. Notably, there were a number of high

quality concept maps which described the material classification and the properties. See the following typical high quality concept maps constructed by students.

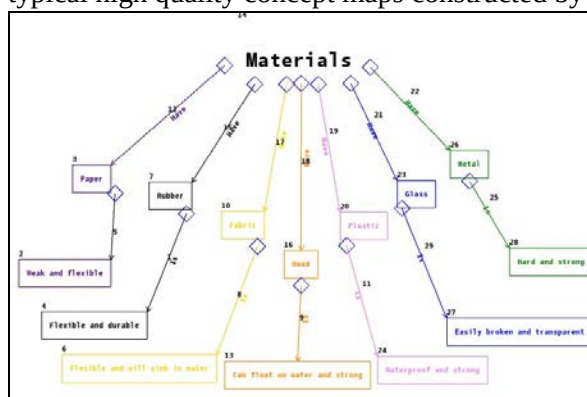


Figure 2a. Concept map A

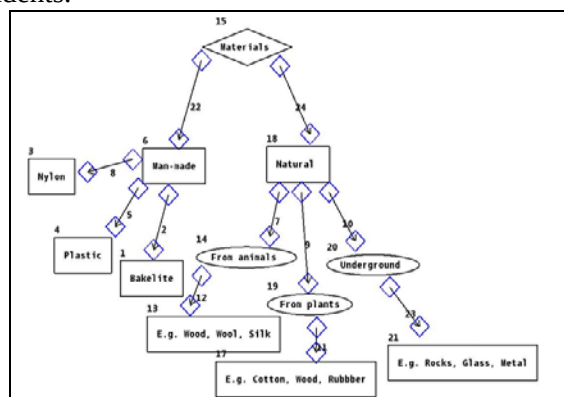


Figure 2b. Concept map B

Students' positive KWL responses on "what I know and what I have learnt" suggested they had learnt more about materials compared to their understanding at the beginning stage of the lessons. They also raised multiple questions at "what I want to know", which reflected their desire and interests in investigating the new knowledge. We selected some excerpts from KWL "What I know".

- Some materials are man-made and some materials are natural.
- There are hard, soft, strong, weak, flexible stiff waterproof and absorbent materials.
- Metal is a good conductor of heat and electricity.
- I know that a thing might be made of many materials.

Reviewing student' Sketchbook work which referred to identifying objects and explaining the properties of the materials, we found that most students could relate their new knowledge with their daily life experiences. This indicated that students could apply their knowledge in the new context and their improvement on their knowledge at the cognitive levels. See the following artifacts we selected:



Figure 3a. Artifact A



Figure 3b. Artifact B



Figure 3c. Artifact C

7. Conclusion

Regarding to the purpose of TPD for technology-facilitated curriculum, Diaconu et al., (2012) stated that teacher content knowledge and pedagogical practice was the impetus for building a strong community of teachers to be readiness of curriculum. He suggested that more evidence is required to establish the link between professional development and the teacher practices that act as mediating factors between the professional development and the instruction experienced by the students. Thus, in this study, we connect the research of TPD with teachers' teaching practices and students' performance. This helps us gain deep insight into teacher changes. From our data analysis, we recognized that long-term and school-based TPD for M5ESC could change teachers' pedagogical orientation on the conducting students' activities, asking questions and the patterns of interacting with students and the technology use in the class. The pedagogical practices would gradually move toward constructivist strategies. The results showed that there were mutual relationships among TPD, curriculum implementation and teacher growth. First, through observing teacher and student performance, TPD will consider some aspects further that we might not emphasized in the regular working sessions, such

as teachers' knowledge of technology integration, and the ways for designing student-centered activities. Second, the curriculum design will be modified to be more elaborated based on our data analysis of students' performance. Third, teacher understanding of constructivist belief and pedagogical practice on the technology integration in class will be gradually transformed over time with the efforts of TPD and their enactment of M5ESC. In the further work, we will focus more on the relationship between teacher changes and the development of TPD. More studies will be conducted for identifying teacher differences of the enactment of the same lesson plan of M5ESC. The work will be used to inform the scaling of M5ESC to another grade level in the school as well as to other schools.

Acknowledgements

The paper is a part of work from project "Bridging Formal and Informal Learning Spaces for Self-directed & Collaborative Inquiry Learning in Science" funded by Singapore National Research Foundation (NRF2011 - EDU002-EL005). We would like to thank team members Gean Chia and Peter Seow, and teachers and their students from our pilot school for working on this project.

References

- An, Y.-J., & Reigeluth, C. (2012). Creating technology-enhanced, learner-centered classrooms: K-12 teachers' beliefs, perceptions, barriers, and support needs. *Journal of Digital Learning in Teacher Education*, 28(2), 54-62.
- Ballone, L.M., & Czerniak, C.M. (2001). Teachers' beliefs about accommodating students' learning styles in science classes. *Electronic Journal of Science Education*, 6(2), 1-43.
- Bielefeldt, T. (2012). Guidance for technology decisions from classroom observation. *Journal of Research in teacher Education*, 44(3), 205-223.
- Brooks, M. (2009). Drawing, visualisation and young children's exploration of "Big Ideas". *International Journal of Science Education*, 31(3), 319-341.
- Bybee, R. W. (2002). *BSCS 5E Instructional Model*. Colorado Springs, CO: Biological Sciences Curriculum Study.
- Carlson, E. (1994). *Staff Development for Multimedia: Coping with Complexity*. Alexandria, VA: National School Boards Association.
- Chiu, M. M. (2004). Adapting teacher interventions to student needs during cooperative learning: How to improve student problem solving and time on-task. *American Educational Research Journal*, 41(2), 365-399.
- Day, C. (1999). *Developing Teachers: the Challenges of Lifelong Learning* (p11). London: Routledge.
- Elmore, R. F. (2002). *Bridging the Gap between Standards and Achievement: The Imperative for Professional Development in Education* (p. 5). Washington, DC: Albert Shanker Institute.
- Ge, X., & Land, S. M. (2004). A conceptual framework for scaffolding ill-structured problem-solving processes using question prompts and peer interactions. *Educational Technology Research and Development*, 52(2), 5-22.
- Gillies, R. M. (2006). Teachers' and students' verbal behaviours during cooperative and small-group learning. *British Journal of Educational Psychology*, 76(2), 271-287.
- Greca, I. M., & Moreira, M. A. (2000). Mental models, conceptual models, and modelling. *International Journal of Science Education*, 22(1), 1-11.
- Kerawalla, L., Petrou, M., & Scanlon, E. (2013). Talk Factory: supporting 'exploratory talk' around an interactive whiteboard in primary school science plenaries. *Technology, Pedagogy and Education*, 22(1), 89-102.
- King, A. (2002). Structuring peer interaction to promote high-level cognitive processing. *Theory into Practice*, 41(1), 34-39.
- Lim, K. Y., Lee, H. W., & Grabowski, B. (2009). Does concept-mapping strategy work for everyone? The levels of generativity and learners' self-regulated learning skills. *British Journal of Educational Technology*, 40(4), 606-618.
- Looi, C. K., Seow, P., Zhang, B., So, H. J., Chen, W.-L., & Wong, L. H. (2010). Leveraging mobile technology for sustainable seamless learning. *British Journal of Educational Technology*, 41(2), 154-169.
- Martin, F., & Ertzberger, J. (2013). Here and now mobile learning: An experimental study on the use of mobile technology. *Computers & Education*, 68(1), 76-85.
- McDougall, A., & Squires, D. (1997). A framework for reviewing teacher professional development programmes in information technology. *Journal of Information Technology for Teacher Education*, 6(2), 115-126.
- Nelson, T. H. (2009). Teachers' collaborative inquiry and professional growth: Should we be optimistic. *Science Teacher Education*, 93(3), 548-580.

- Ottenbreit-Leftwich, A.T., Brush, T.A., Strycker, J., Gronseth, S., Roman, T., Abaci, S., vanLeusen, P., Shin, S., Easterling, W. & Plucker, J. (2012). Preparation versus Practice: How Do Teacher Education Programs and Practicing Teachers Align in Their Use of Technology to Support Teaching and Learning? *Computers & Education*, 59(2), 399-411.
- Scribner, J. P., Cockrell, K. S., Cockrell, D. H., & Valentine, J. W. (1999). Creating professional communities in schools through organizational learning: An evaluation of a school improvement process. *Educational Administration Quarterly*, 35(1), 130-160.
- Stein, M.K., Smith, M.S., and Silver, E.A. (1999). The development of professional developers: learning to assist teachers in new setting in new ways. *Harvard Educational Review*, 69, 237-69
- Wildy, H., & Wallace, J. (1995). Understanding teaching or teaching for understanding: Alternative frameworks for science classrooms. *Journal of Research in Science Teaching*, 32(2), 143-156.
- Weinberger, A., & Fischer, F. (2006). A framework to analyze argumentative knowledge construction in computer-supported collaborative learning. *Computers & Education*, 46(1), 71-95.

Enhancing Outside-class Learning using Ubiquitous Learning Log System

Noriko UOSAKI^{a*}, Hiroaki OGATA^b, Mengmeng LI^b, Bin HOU^b, & Kousuke MOURI^b

^a*Center for International Education and Exchange, Osaka University, Japan*

^b*Faculty of Engineering, The University of Tokushima, Japan*

*uosaki@ciee.osaka-u.ac.jp

Abstract: In this paper, we have tackled one of the major problems in English education in Japan, the learning time shortage problem. In order to solve this problem, we have used the system called SCROLL (System for Capturing and Reminding Of Learning Log) developed by our team. We conducted an evaluation to examine whether our system could boost up outside-class learning time. We provided the participants, 24 university freshmen, with an *e-book* application as a reading material together with the system and encouraged them to learn outside-class. The result showed that outside-class learning time dramatically increased only when they read an *e-book* together with the System even though no statistically significant difference was detected since individual differences were so large. Though we expected that interesting outside-class learning materials would push them to learn more outside class, the result showed that it was the System that pushed them to study outside class. Whether they used *e-book* or not, the average learning time of without-SCROLL learning was almost the same. Therefore the use of the System could be one of the factors which contributed to the students' more involvement in outside-class learning. We believe that it will lead to compensation of a lack of learning time.

Keywords: mobile-assisted language learning, vocabulary learning, learning time, learning log

1. Introduction

English language has become a global common language of our age. Therefore EFL (English as a Foreign Language) education is crucial for non-English speaking countries. Educators in these countries have been struggling with various problems they face in their education system. Japan is not an exception. Our country is facing serious problems in terms of English proficiency. In fact Japan ranked the third worst out of 30 Asian countries in TOEFL test 2011 (cited from TOEFL official website)*

As one of the factors that have caused this disappointing result, it has been pointed out that learning time of English at school is not sufficient: 630–650 hours during 6 years of junior and senior high school education (Curriculum Guidelines by MEXT: Ministry of Education, Culture, Sports, Science and Technology), plus 135–180 hours, for instance, during college years at Osaka university (based on Osaka University enrollment regulations). Shortage is apparent when we consider the fact that 2,200 hours is necessary for English speakers to achieve general professional proficiency level** of Japanese language according to the Foreign Service Institute (FSI) of the US Department of State.***

* Test and Score Data Summary for TOEFL® Internet-based and Paper-based Tests (2011).
http://www.ets.org/s/toefl/pdf/94227_unlweb.pdf

** The ILR (US Government Interagency Language Roundtable) has guidelines for speaking, reading, listening, writing and translation. (cf. <http://web.archive.org/web/20071010042447/http://www.govtilr.org/ILRscale2.htm>)

*** The Foreign Service Institute (FSI) of the US Department of State has compiled approximate learning expectations for a number of languages based on the length of time it takes to achieve Speaking 3: General Professional Proficiency in Speaking (S3) and Reading 3: General Professional Proficiency in Reading (R3) (cf. <http://web.archive.org/web/20071014005901/http://www.nvtc.gov/lotw/months/november/learningExpectations.html>)

In fact, the Ministry of Education, Culture, Sports, Science and Technology introduced once-a-week English class (45 minutes for one class and 35 classes a year) for elementary school 5th and 6th graders from 2011. But it only added 52.5 hours to total learning hours. It is far from satisfactory to solve the lack of learning time. We need to cope with this shortage problem. If it is difficult to modify the school curriculum, and if it is impossible to increase in-class learning time, there is no other way but to encourage students to study outside-class. Some drastic measures need be found to cope with this problem and it is highly expected that the emerging mobile technology and its output, mobile assisted language learning or MALL are one of the key issues to solve the problem.

Our main objective in this study is to let learners get more involved in outside-class learning with our developed system called SCROLL (cf. Section 3). Our hypothetical question is: Does SCROLL contribute to the solution of lack of learning time? We had conducted an experiment to find an answer to this question in our previous study (Uosaki et al., 2012) (hereafter we call it Evaluation I). The result showed that their average outside-class learning time was extremely low (cf. Section 4.1). SCROLL has its original contents, but they are task-based learning contents for Japanese language learners. Basically SCROLL is for logging and sharing learning experience and not a learning material itself. Therefore we felt a strong necessity to find a good learning material for outside-class learning. It is possible to upload any learning contents to SCROLL technically but the copyright problem hampers its uploading. Therefore in this study we designed an outside-class learning scenario introducing some appealing reading materials together with SCROLL and examined how effectively SCROLL encouraged students' outside-class unsupervised self-learning. "Unsupervised", by which we mean the situation where learners are not attended by the teacher and it is up to learners whether they get involved in learning.

2. Related works

2.1 Learner Autonomy and Learning Motivation

There are very few studies in which they challenged to boost up outside class learning. In most cases their research topics are learner autonomy, coined word by Henri Holec, which is defined as "the ability to take charge of one's own learning" (Holec, Henri, 1981) or learning motivation especially in the field of language learning since a language is a subject which takes a substantial amount of time to master. Shirono (2009) reported that by letting their students keep their learning reports and submit them to their teacher, it helped them get more committed to outside-class learning. Tan (2012) explored the pedagogy of blended language learning to promote learner autonomy. But we could find no research studies where they challenged it with mobile ubiquitous technology-enhanced learning even though it is one of the most active research areas on educational technology at present described as below.

2.2 Mobile Assisted Language Learning

MALL is a growing research area attracting the attention of scholars all over the world. Mobile language learning has always been among top research topics in mobile learning since early 2000s (the epoch of mobile learning). (Ogata et al., 2008; Ogata et al., 2009; Kukulska-Hulme, 2010; Read et al., 2010; Starostenko et al., 2010; Lumsden et al., 2010).

In the earlier days, it often focused on the simple use of SMS (Short Message Service) and mobile e-mails as a means of delivering learning contents, most often for the vocabulary learning or facilitating interactions between learners. Along with the use of SMS and e-mails, there appeared quite a few studies exploring L2 learners' listening skill using iPods or podcasting (Kiernan and Aizawa, 2004; Thornton and Houser, 2005; Levy and Kennedy, 2005; Gromik, 2008).

Then, there followed researches into developing more sophisticated systems such as context-aware, user-customized systems using PDA, then subsequently smartphones (Ogata et al., 2004; Stockwell, 2007; Chen and Chung, 2008; Li et al., 2010; Underwood et al., 2010). Since mobile and ubiquitous technology is a fast-evolving, constantly advancing field, its infinite potential is inevitably expected to contribute to boosting up students' outside-class self-learning.

3. SCROLL

Since 2009, we have developed a system called SCROLL (System for Capturing and Reminding of Learning Log) as one of the Sakigake projects (cf. Ogata et al., 2010). SCROLL helps learners log their learning experiences and share them with others. Users register what they have learned, which we call “ubiquitous learning log objects (ULLOs)”, to the system and view ULLOs uploaded by themselves and others. Then the system automatically generate quizzes to help learners to recall their past ULLOs and to shift them from short-term memory to long-term one.

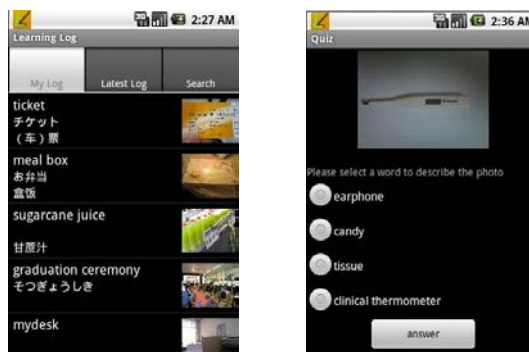


Figure 1. SCROLL interface of Android mobile phone (My Log List (left) and Quiz (right))

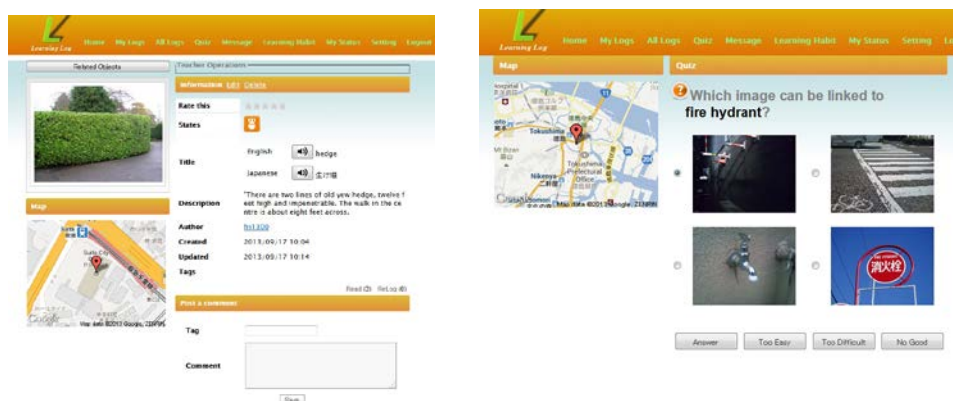


Figure 2. SCROLL interface on the Web (My Log (left) and Quiz (right))

Learners are able to watch other learners’ ULLOs and if they like other learners’ ULLOs, they can “relog” them to their own pages just like “retweet” in Twitter so that ULLOs uploaded by other learners can be their own ULLOs. This system is implemented both on android smartphone platforms (https://play.google.com/store/apps/details?id=jp.ac.tokushima_u.is.ll&hl=ja) and on the web (<http://ll.is.tokushima-u.ac.jp/learninglog/signin;jsessionid=4ED1BCA735AA1FD9A922C77A1FFFD7DC>). It is designed to support learners’ autonomous self-learning.

4. Evaluation

4.1 The average outside-class learning time in our previous evaluation (Evaluation I)

In order to find the answer to our hypothetical question: Does SCROLL contribute to the solution of lack of learning time?, we had conducted an evaluation with university freshmen in terms of English vocabulary learning with/without SCROLL in Evaluation I (Uosaki et al., 2012). Table 1 shows the average outside-class learning time for both groups for three weeks. The average learning time of SCROLL group was 142.3 minutes (47.4 minutes per week / only 6.8 minute per day), while

without-SCROLL group was 130.7 minutes (43.6 minutes per week / only 6.2 minute per day). This indicates that the test group more committed to vocabulary learning than the control group, though the difference was small and not statistically significant. In fact it was far from saying our system contributed to the solution of lack of learning time.

Table 1: Average outside-class learning time in Evaluation I.

	Outside-class Learning Time (min) Mean (SD)	<i>t</i>	Effect Size (<i>d</i>) ¹
A (with System)	142.25 (106.14)	0.391*	0.53 (Medium)
B (without System)	130.7 (105.2)		

Since we learn words from contexts, we need contexts, in other words, we need some reading materials for gaining new vocabulary. Since the copyright problem hampers uploading contents to SCROLL, we looked over some appealing outside-class learning materials, such reading materials as it is so tempting that students cannot help but feel like reading more. And we found an *e-book* application which runs on Android smartphones with a good collection of mysteries. In this study, we conducted an evaluation (hereafter, we call it Evaluation II) with a combination use of SCROLL and *e-book* application to find answers to the hypothetical question mentioned above.

4.2 Method

Twenty-four university freshmen of Basic English class majoring health sciences at the University of Tokushima participated in the experiment. They all reported they had Internet-connected PCs at home. We employed a crossover research design involving two comparison groups, with 12 students in each group, counterbalanced by scores at Pre-test. Each group of students engaged in learning under the following two conditions: study in-class with a textbook and study outside-class with 1) reading *e-book* contents and uploading new words to SCROLL, and 2) reading *e-book* contents and making a vocabulary book on spreadsheets. The order of the conditions will be rotated, so that each group will have a different start condition. The evaluation was carried out over 4 weeks. Each group had experience of each of the two learning modes for 2 weeks, as indicated in the Table 2

Table 2: The evaluation design.

	Pre-test	Phase 1		Phase 2		Survey and focus groups
Group A		<i>e-book</i> with SCROLL	Post-test (1)	<i>e-book</i>	Post-test (2)	
Group B		<i>e-book</i>		<i>e-book</i> with SCROLL		

¹Effect size is a measure of the strength of the relationship between two variables in a statistical population. Effect sizes are calculated as shown below and usually described as "small", "medium" and "large".

$$d = \frac{M_{group1} - M_{group2}}{SD_{pooled}} \quad SD_{pooled} = \sqrt{(SD_{group1}^2 + SD_{group2}^2)/2}$$

According to APA Publication Manual 5th edition (2001), reporting effect sizes is required when submitting research papers to academic journals:

For the reader to fully understand the importance of your findings, it is almost always necessary to include some index of effect size or strength of relationship in your Results section. (p. 25)

Android *e-book* application was installed to each Galaxy Tab SC-01C produced by Samsung before evaluation. They were delivered to all the participants on one-to-one basis. They could use the Tabs anywhere anytime during the evaluation. They studied with Galaxy Tabs as well as home PCs and classroom PCs. Since most participants had never used the device, they were delivered to them one week before the experiment started for letting them get used to it and the System. On the delivery day, they had a briefing on how to use the Tabs, *e-book* and SCROLL (cf. Figure 3).



Figure 3. Briefing on the delivery day

Before Phase 1 started, the students took a pre-test, which is a web-based vocabulary test with multiple-choice style quizzes. During the phase without SCROLL, they used a spreadsheet software to make their own vocabulary books using home PCs and classroom PCs. After making their own wordbooks on spreadsheets, they uploaded their files to LMS (Learning Management System) at least once a week. We chose spreadsheet vocabulary learning + LMS because by doing so, the teacher had the ability to watch and evaluate their learning status. During both phases, the students were assigned to read mystery novels with *e-book* for outside-class learning. They were informed that their commitment to vocabulary learning directly reflected their grades. At the conclusion of each phase, the subjects underwent a post-test, the same type of web-test as Pre-test. Further data was collected from the participants by means of questionnaires and the log data stored in the server. Focus group session was held at the end of the whole evaluation in order to attain more detail information on how they got committed to vocabulary learning with SCROLL and *e-book*.

4.3 Results

(1) Outside-class Learning Time

The students reported their vocabulary learning time outside the class to the teacher every week by means of answering questionnaires on the web. Table 3 shows the average outside-class learning time for both groups. The average learning time of SCROLL session was 141.04 minutes, while that of without SCROLL session was 91.9 minutes. This result indicates that the students during SCROLL System learning more committed to vocabulary learning than during without SCROLL learning, though the *t*-value (1.28) did not indicate its statistical significance. This result agrees with that of Evaluation I.

Table 3: Average Outside-class Learning Time(/two weeks).

	Outside-class Learning Time (min) Mean (SD)	<i>t</i>	Effect Size (d)
With SCROLL	141.04 (151)	1.28*	0.37 (Small)
Without SCROLL	91.88 (115)		

**p* = 0.11

(2) Test Results

The Pre-test and Post-test (1) (2) were the same test as the one used in Evaluation I, a web-based vocabulary test called V-check test (<http://www.wordengine.jp/vflash/levelcheck>). Test-takers take the test for about 10 minutes and the system predicts each test-taker's command of English vocabulary. The full mark is 20,000 points and each test taker's result represents that he is estimated to know that amount of English words out of 20,000 basic English words. The test contents differ every time they take the test.

The results of Pre-test, Post-test with-SCROLL session, and Post-test without-SCROLL session are shown in Table 4. Pre-test average was 5,603 (SD: 1,439). The average score of Post-test conducted right after with-SCROLL session was 7,310 (SD: 3,058). The average score of Post-test conducted right after without-SCROLL session was 5,970 (SD: 1,383). With-SCROLL session shows a large improvement (Mean: 5,603⇒7,310), while during without-SCROLL session they did not make much progress (Mean: 5,603⇒5,970) though the highest *t*-value was 2.31 and no statistically significant difference was detected in any case.

Table 4: Pre-test and Post-test results (full mark: 20,000).

	① Pre-test Mean (SD)	② Post-test with SCROLL Mean (SD)	③ Post-test without SCROLL Mean (SD)	① vs. ② <i>t</i> Effect Size (<i>d</i>)	① vs. ③ <i>t</i> Effect Size (<i>d</i>)	② vs. ③ <i>t</i> Effect Size (<i>d</i>)
Group A+B	5,603 (1,439)	7,310 (3,058)	5,970 (1,383)	2.31 * 0.72 (M)	0.74** 0.26 (S)	2.26 *** 0.57 (M)

p*=0.01 *p*=0.23 ****p*=0.0167

V-check test (<http://www.wordengine.jp/>)

4.4 Discussion

(1) Outside-class Learning Time Reconsidered

One major aim of this study was to examine whether the System could increase out-side learning time to solve one of the problems in English education in Japan, lack of learning time at school. In order to enhance the level of average learning time, we used an *e-book* application for outside-class learning.

Table 5: Comparison of average outside-class learning time between Evaluation I and II.

Evaluation I				Evaluation II			
	Outside-class Learning Time per week (min) Mean (SD)	<i>t</i>	Effect Size (<i>d</i>)		Outside-class Learning Time per week (min) Mean (SD)	<i>t</i>	Effect Size (<i>d</i>)
With SCROLL without <i>e-book</i>	47.4 (35.38)	0.39*	0.11 (None)	With SCROLL & <i>e-book</i>	70.5 (75.26)	1.25**	0.37 (Small)
Without SCROLL & <i>e-book</i>	43.6 (35.07)			With <i>e-book</i> Without SCROLL	45.9 (57.27)		

p* = 0.69 *p* = 0.22

In Evaluation I, the average outside-class learning time of the test-group (with-SCROLL System group) was 47.4 minutes per week, while that of the control group (without-SCROLL System group) was 43.6 minutes. In Evaluation II, the average outside-class Learning time of with-SCROLL session was 70.5 minutes per week, while that of without-SCROLL session was 45.9 (cf. Table 5).

We had expected that the average outside-class learning time would increase for the both learning modes in Experiment II, whether they used SCROLL or not, because we looked over the whole

collection of *e-book* contents and picked out some interesting stories for outside-class learning materials. The result, however, was not what we had expected. Whether they used *e-book* or not, the average learning time of without-SCROLL learning was almost the same (43.6 minutes without the System in Experiment I and 45.9 minutes without SCROLL in Experiment II).

However, the average outside-class learning time of with-SCROLL and with-*e-book* session increased from 47.4 minutes to 70.5 minutes per week. Since the participants of Experiments I and II were different, there is a possibility that other factors made outside-class learning increase. Though we expected that interesting outside-class learning materials would push them to learn more outside class, the result shows that it was the System that pushed them to study outside class.

Even though the increase rate was as high as 48.7% (47.42 minutes $\Rightarrow$ 70.52 minutes), as the SD values shows in Table 5, individual differences were so large that no statistically significant differences were detected. Therefore we examined furthermore about what factors had influenced their outside-class learning time by analyzing the questionnaire and focus group.

From the open-ended comments of the participants whose outside-class learning time was short, some factors which had decreased their outside-class learning time were found as follows:

- 1) I prefer paper books to *e-book*, because it is not easy for me to handle (plurality opinion).
- 2) I had to prepare some tests for other classes and did not have enough time to read (plurality opinion).
- 3) Before I noticed, it was running out of battery and I could not read when I wanted to (plurality opinion).
- 4) I was busy with my club activity (plurality opinion).
- 5) It was difficult to handle Galaxy Tab.
- 6) I do not like *e-book* because I cannot put annotations.
- 7) It was hard to find time to read.
- 8) *E-book* was not easy to handle, which made me hesitant in reading.
- 9) It was bothering to charge the device.
- 10) The story was difficult to read.
- 11) I do not like to read in the first place.
- 12) Even though I set it manner mode, it produced some beep sound and I got surprised and I did not like it.

Apparently, some participants did not like the *e-book*, and some extra activities such as test preparations, club activities prevented them from learning at home. On the other hand, we see some open-ended comments from the participants who got involved in more outside-class learning, and had favorable opinions on the *e-book*:

- 1) It was easy to consult the dictionary, so it was easy to go on reading.
- 2) When I touched an English word, then its Japanese translation appeared and I liked it very much.
- 3) I prefer tablets for reading.
- 4) I liked the illustrations.
- 5) The story was very interesting, so I could get absorbed in reading.

They used the same *e-book* application, but their reactions were quite opposite. Therefore the individual differences such as preference, lifestyle, and motivation reflected the results of outside-class learning time. And it is very difficult to eliminate these factors.

We see some open-ended comments which were in favour of SCROLL from the participants who got involved in more outside-class learning:

From the results of the questionnaires and focus group, some factors by which SCROLL had boosted up their outside-class learning time have also been found. Followings are some open-ended comments in favour of SCROLL:

- 1) It was good because I could learn words from other classmate uploaded words.
- 2) The words which I uploaded appear as a quiz, and I think it is a good way to memorize words (plurality opinion).
- 3) I thought it was convenient.
- 4) It was easy to remember by answering quizzes.
- 5) It was fun to answer quizzes (plurality opinion).
- 6) Answering quizzes reminds me of the words forgotten.
- 7) I did not like to make a vocabulary book on spreadsheets.
- 8) “Re-log” function was very convenient.
- 9) I forget new vocabulary very easily, but it was a good way to review by answering quizzes.
- 10) It was easy to handle.

From these favourable comments, it is assumed that SCROLL had boosted up their outside-class learning time.

On the other hand, some weak points have been found such as:

- 1) There came out a quiz of a word which I did not upload and I did not like it.
- 2) Sometimes, some weird translation came out. So, a dictionary function as a translator of an uploaded English word was not good enough.
- 3) Some distractors in quizzes are so simple that it was very easy to choose right answers.
- 4) It was troublesome to log into the system and input new vocabulary

These negative opinions were almost about a quiz function. The quiz function of SCROLL has now been under improvement. Especially Comment #3) is expected to be solved soon.

Figure 4 shows the result of the questionnaire by which they were asked if vocabulary learning using SCROLL was effective. Together with ‘yes’ and ‘weak yes’ answers, about 60% admitted the effectiveness of SCROLL. This result shows good consistency with those of Evaluations I and II.

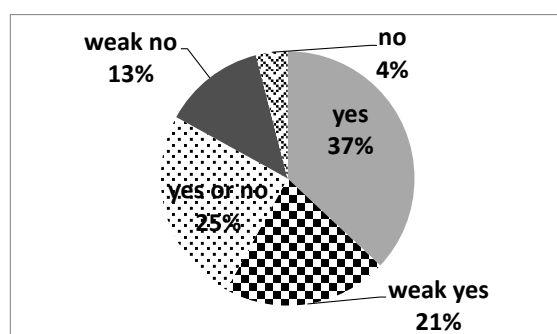


Figure 4. Was vocabulary learning effective using SMALL System?

Therefore the use of the System could be one of the factors which contributed to the students’ more involvement in outside-class learning. We believe that it will lead to compensation of a lack of learning time, which is one of the serious problems of English education in Japan.

5. Conclusion and Future Works

This study is aiming for contributing to the solution of one of the major problems we are facing in English education in Japan: lack of learning time at school. In order to solve the problem, we have used SCROLL. Our main objective was the promotion of outside-class learning. The evaluation was conducted to find an answer to the following hypothetical question. 1) Does SCROLL contribute to the solution of lack of learning time? In our previous study, it turned out that the students hardly learned outside-class (Evaluation I). Therefore in Evaluation II, we introduced an *e-book* application for outside-class learning in order to boost up outside-class learning time. Outside-class learning time increased only when they read an *e-book* together with the System even though no statistically significant difference was detected. During without-System session, outside-class learning time did not increase. In fact there were a lot of participants who expressed favorable opinions about the System. Therefore the use of the System could be one of the factors which contributed to the students' more involvement in outside-class learning. We believe that it will lead to compensation of a lack of learning time, which is one of the serious problems of English education in Japan.

As one of our future works, by utilizing sensor technology, customized learning recommendation system is under development so that the system can give learners recommendations actively and aggressively at an appropriate timing and an appropriate place. The system does not just wait for a learner to upload a new word, but it autonomously lets a learner learn new word by recommending him/her according to their situation. It is expected that the smartphones will be equipped more sophisticated sensors in the future and the device will know learners better to catch their learning habits more accurately. Since we usually have only one teacher per class and what the teacher can do is limited, peer-to-peer collaboration is necessary for successful seamless learning. Therefore as another future work, we are planning to add an appealing social network type of function, in order to promote the students' outside-class learning.

Acknowledgements

This research work was supported by Japan Science and Technology Agency, PRESTO, and the Grant-in-Aid for Scientific Research No.21650225 from the Ministry of Education, Science, Sports, and Culture in Japan.

References

- Chen, C.-M. and Chung, C.-J. (2008). Personalized mobile English vocabulary learning system based on item response theory and learning memory cycle, *Computers & Education*, 51, 624–645.
- Gromik, N. (2008). iPods in the EFL classroom: a tool for independent learning, *JALT CALL Journal*, 5(3), 57–66.
- Holec, H. (1981). *Autonomy and Foreign Language Learning*. Oxford: Pergamon Press.
- Kiernan, P., and Aizawa K. (2004). Cell phones in task based learning - Are cell phones useful language learning tools?, *ReCALL Journal*, 16(1), pp.71–84.
- Kukulska-Hulme, A. (2010). Charting unknown territory: models of participation in mobile language learning, *International Journal of Mobile Learning and Organisation*, 4, 116–129.
- Levy, M. and Kennedy, C. (2005). Learning Italian via mobile SMS, In: Kukulska- Hulme, A. and Traxler, J. (eds.) *Mobile Learning: A Handbook for Educators and Trainers*. London: Taylor and Francis, pp.76–83.
- Li, M., Ogata, H., Hou, B., Hashimoto, S., Uosaki, N., Liu, Y. and Yano, Y. (2010) Development of adaptive vocabulary learning via mobile phone, e-mail, *Proceedings of WMUTE'10* (pp.34–41), Kaohsiung, Taiwan.
- Lumsden, J., Leung, R., D'Amours, D. and McDonald, D. (2010). ALEX©: a mobile adult literacy experiential learning application, *International Journal of Mobile Learning and Organisation*, 4, 172–191.
- Ogata, H., Akamatsu, R., Mitsuhashi, H., Yano, Y., Matsuura, K., Kanenishi, K., Miyoshi, Y., and Morikawa, T. (2004). TANGO: Supporting Vocabulary 98 Bibliography Learning with RFID tags, *International Workshop Series on RFID*, Tokyo, Nov.10, 2004.
- Ogata, H., Hui, G. L., Yin, C., Ueda, T., Oishi, Y. and Yano, Y. (2008). LOCH: Supporting mobile language learning outside classrooms, *International Journal of Mobile Learning and Organisation*, 2, 271–282.

- Ogata, H., Matsuka, Y., El-Bishouty, M. M. and Yano, Y. (2009). LORAMS: Linking physical objects and videos for capturing and sharing learning experiences towards ubiquitous learning, *International Journal of Mobile Learning and Organisation*, 3, 337–350.
- Ogata, H., Hou, B., Li, M., El-Bishouty, M. M., Uosaki, N. and Yano, Y. (2010). What if we can log our ubiquitous learning?, *Proceedings of ICCE'10* (pp.360–367), Putrajaya, Malaysia.
- Read T., Barcena, E. and Rodrigo, C. (2010). Modelling ubiquity for second language learning, *International Journal of Mobile Learning and Organisation*, 4, 130–149.
- Shirano, H. (2009) An attempt to increase outside-class learning time by submitting learning reports: Seeking for fostering autonomous self-learners ("Gakushu houkokusho" niyoru kateigakushuujikan wo fuyasu kokoromi: jiritsu shita gakushuusha no ikusei wo mezashite) (in Japanese), *SELHi report of Mie Prefectural Kawagoe Senior High School*. <http://www.mie-c.ed.jp/hkawag/selhi/reports/report28.pdf>
- Starostenko, O., Alarcon-Aquino, V., Lobato-Morales, H. and Sergiyenko, O. (2010). Computational approaches to support image-based language learning within mobile environment, *International Journal of Mobile Learning and Organisation*, 4, 150–171.
- Stockwell, G. (2007). Vocabulary on the move: Investigating an intelligent mobile phone-based vocabulary tutor, *Computer Assisted Language Learning*, 20, 365–383.
- Tan, M-C. (2012) Learner Autonomy in listening strategy use and online English learning. *Abstracts of the 20th KOTESOL International Conference* Seoul, Korea
<http://koreatesol.org/sites/default/files/pdf/Session%20abstracts%20-%20all.pdf>
- Thornton, P. and Houser, C. (2005). Using mobile phones in English education in Japan, *Journal of Computer Assisted Learning*, 21, 217–228.
- Underwood, J., Luckin, R. and Winters, N. (2010). m-iLexicon: Harnessing resources for personal and collaborative language inquiry, *Proceedings of ITEC'10* (pp.87–98), Kortrijk, Belgium.
- Uosaki, N., Ogata, H., Sugimoto, T., Li, M. and Hou, B. (2012). Towards Seamless Vocabulary Learning: How We Can Entwine In-class and Outside-of-class Learning. *International Journal of Mobile Learning and Organization*, 6(2), 138–155.

Teacher Thinking and Affordances of TouchPad Technology: An Ongoing Study of Teacher Adoption of iPads in Higher Education

Daniel CHURCHILL*, Jie LU, & Tianchong WANG

The University of Hong Kong

*dchurch@hku.hk

Abstract: TouchPad mobile devices (e.g., iPads) are increasingly being used in educational contexts. Growing investment is planned by higher education institutions in Hong Kong and by the HKSAR Education Bureau in relation to educational uses of TouchPad technology. However, current research into educational applications of this technology is limited. This paper reports an ongoing qualitative study that investigates how higher education teachers use iPad technology to facilitate their practice. The emergent study results provide insight into both the educational affordances of iPad technology and the ways in which teachers' personal or private theories mediate these affordances and transform through the process. The study outcomes will contribute to theoretical understanding of higher education teacher changes through adoption of technology. Furthermore, the outcomes will provide a set of recommendations for applications of TouchPad technology in higher education and ways to support teachers to effectively adopt such technology in their practices.

Keywords: mobile learning, iPad, affordances, teacher private theories

1. Introduction

TouchPad devices are increasing becoming dominant information technology in hands of people. Statistics from major sources, such as Nielsen.com, strongly suggest huge increase in consumer demand for this technology and related software, services and content. Murphy (2011) refers to this technology as the Post-PC devices. Most notable of these devices is the Apple iPad. It is expected that by 2015, global sales of iPad devices will reach 395 million (see Telecomasia, 2010). Majority of TouchPad devices sold globally in 2011 were iPads (Herald Sun, 2011), although devices from Samsung are increasingly challenge Apple's dominance. Hong Kong is leading the adoption of iPads in the World and with one of the fastest broadband connectivity in the World, native services, software and content are likely expand rapidly. According to recent press coverage, 17% of Hong Kong people own a TouchPad device, a rate that is six times higher than the global average (Herald Sun, 2011). Besides Apple and Samsung, other major hardware designers and manufactures are in pursuit of attracting a share of market place though own devices, e.g., the Dell Streak, ASUS EEE Pad, Blackberry Play Pad, Lenovo LePad, Cisco Cius and HP Slate.

The Horizon Report 2011 emphasizes the importance of mobile technology and adds that this technology coupled with cloud computing will have strong impact on education (New Media Consortium, 2011). In Hong Kong, the Education Bureau's Pilot Scheme on Textbooks and E-learning Resources in Schools emphasizes the importance of the design of educational content such as learning objects and e-books (see Education Bureau, 2010). The Hong Kong Government Research Agency, ASTRI, is investing in the development of TouchPad devices to deliver such e-learning resources (see ASTRI, 2010). Hong Kong universities are likely to be expected to follow what is established in the school system. Significant investment is taking place with very limited guidelines on effective integration of TouchPad technology in education at all levels. Although Liaw, Hatala and Huang (2010) suggest mobile technologies have the power to improve education, however, there is a lack of recommendations for educators as the current research is still in an embryonic stage.

We concur with Banister (2010), Klopfer and Squire (2005), and Ostashevski and Reid, 2010, that it is important to study teacher thinking and uses of this technology, explicate possible uses (affordances),

and articulate recommendations for successful educational applications and supporting intervention for teacher adoption in higher education. Our further effort concentrates of understanding features of effective design of Apps and systems for education. In this paper, we discuss a study that investigates teacher changes through adoption of iPads, kinds of tools they use and how such technology facilitates aspects of their practices.

2. Affordances of Mobile Technology and Education

The literature related to early adoption of mobile technology suggests that it might assist students to learn any time, anywhere, by empowering them “to access internet resources and run experiments in the field, capture, store and manage everyday events as images and sounds, and communicate and share the material with colleagues and experts throughout the world” (Sharples, Corlett & Westmancott, 2002, p. 222). For Luchini, Quintana and Soloway (2004), the key benefit of such mobile technology is that powerful personal devices can “provide access to tools and information within the context of learning activities” (p.135). For Hsieh, Jang, Hwang and Chen (2011) mobile technology has potential to support students’ reflection leading to improved learning achievement when there is an appropriate match between a teacher’s teaching style and students’ learning style. Research on teachers’ use of mobile technology to assist their teaching should provide ideas regarding uses of such technology in achieving learning outcomes. These early reports explored uses of handheld portable digital assistants (PDAs) had been used in education. Nowadays, The iPads can overcome the key limitations of PDAs and smart phones, identified in the education literature as (1) small screen real-estate with (2) limited interactivity (see Churchill, Kennedy, Flint & Cotton, 2010; Churchill & Hedberg, 2008; Song & Fox, 2008; Jones, Buchanan, & Thimbleby, 2003; Luchini, Quintana & Soloway, 2004). Apple iPads might be a “transformative technology” that can help to create flexible, collaborative, and inquiry-oriented learning environments, but only if appropriate models for their use are developed.

Affordance is a useful concept that can be applied to interpret how teachers engage technology in their practice. It includes actual uses, and those uses that emerge in their practice. How iPads will be used in higher education depends largely on teachers’ understandings of affordances of this technology. Norman (1988) defines affordances as “the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used” (p.9).

For Barnes (2000), a teacher’s use of new technology in teaching and learning is carried out with a belief that this technology will afford learning in some way. Klopfer and Squire (2005) describe five potential educational affordances of PDAs: (1) portability, as handhelds can be taken to different locations; (2) social interactivity, as handhelds can be used to collaborate with other people; (3) context sensitivity, as handhelds can be used to gather real or simulated data; (4) connectivity, as handhelds enable connection to data collection devices, other handhelds, and to a network; and (5) individuality, as handhelds can provide scaffolding to the learners. Patten, Sánchez and Tangney (2006) present a framework that consists of the following affordances of PDA technology: administration, referential, interactive, microworld, data collection, location awareness, collaboration. Liaw, Hatala and Huang (2010) suggest five affordances of mobile technology for education: (a) educational content and knowledge delivery, (b) adaptive learning applications, (c) interactive applications, (d) individual applications, and (e) collaborative applications. Churchill and Churchill (2008) expanded upon these studies and examined a teacher’s use of PDA technology. Their study articulated a number of affordances of PDA technology including as a multimedia access, connectivity, capture, representational and analytical tool. A summary of these studies is presented in Table 1. These affordances from the literature are sorted through our analysis into emerging groups that include: (a) resources tool, (b) connectivity tool, (c) collaborative tool, (d) capture tool, (e) analytic tool, (f) representational tool, and (g) administration tool. These groups are used as an analytical framework for understanding affordances that emerge in this study.

Table 1: Affordances of PDA technology across the relevant studies

<i>Klopfer and Squire (2005)</i>	<i>Patten, Sánchez and Tangney (2006)</i>	<i>Churchill and Churchill (2008)</i>	<i>Liaw, Hatala and Huang (2010)</i>	<i>Summary of affordances emerging from across the studies</i>
• Portability • Social interactivity (3*) • Context sensitivity (4) • Connectivity (2, 3) • Individuality (1)	• Administration (7) • Referential (1) • Interactive resource (1) • Microworld environment (1) • Data collection (4) • Location awareness (4) • Collaboration (3)	• Multimedia access (1) • Connectivity tool (2) • Capture tool (4) • Representational tool (6) • Analytical tool (5)	• Educational content and knowledge delivery (1) • Adaptive learning applications (1) • Interactive applications (3) • Individual applications (6) • Collaborative applications (3)	1. Resources 2. Connectivity 3. Collaborative 4. Capture 5. Analytical 6. Representational 7. Administration

* Corresponds to an affordance listed in the summary (final column)

3. iPads in Education

There is a growing need for a more applicable framework to provide teachers, educational policy-makers and researchers with a better representation of the affordances of emerging TouchPad technology and how such technology influences and transforms people who adopt it. Current studies involving iPads in education provide some useful but limited suggestions.

The Catholic Education-Diocese of Paramatta in Australia experimented with iPads in eight primary and three secondary schools (Catholic Education-Diocese of Paramatta, 2010). This trial found that iPads were effective as: (a) support for learning in various settings due to portability and fit-for-task suitability, (b) support for student engagement and quick access to apps that students require for a particular learning task, and (c) students of all levels can use apps, especially for reinforcement and rote learning of basic concepts.

The ‘Step Forward’ pilot implementation of iPads at the Trinity College of the University of Melbourne suggests this technology supports different learning styles and allows students to achieve their goals faster (Jennings, Anderson, Dorset & Mitchell, 2011). Furthermore, it is suggested that iPads are more effective than other computing technology such as laptops, and using this technology resulted in reduced printing and paper use. A survey of student and teacher experiences at the Trinity College shows that iPads are overwhelmingly recommended for use (76.2 % of staff and 80% of students). For Jennings, Anderson, Dorset and Mitchell (2011) advantages of iPads include educational flexibility and value, low cost, size and weight, battery life, low maintenance need, and touch screen. Furthermore, Murphy and Williams (2011) suggest iPads are effective technology for presentation of class materials via multimedia systems. Other suggested advantages of iPads include size, battery life, instant on, transition between applications, multi-touch screen, cost, e-reader, multimedia support and playback, and connection to multimedia systems. Ostashevski and Reid (2010) add that the key advantage of iPad is that it can be used as a multimedia database. Other advantages suggested include ease of interaction via the touch screen, screen size, controllable multimedia playback, sound volume, and data collection capabilities.

Forty teachers from a number of faculties at the University of San Francisco used iPads over six months in 2011 (Bansavich, 2011). Implementation was monitored by the university’s Center for Instruction and Technology. It was noted that the key advantage of iPads for higher education include

Table 2:

Summary of positive characteristics and educational uses of iPad devices from literature (Bansavich, 2011; Beebe, 2011; Catholic Education-Diocese of Parramatta, 2010; Jennings, Anderson, Dorset & Mitchell, 2011; Murphy & Williams, 2011; Ostaszewski & Reid, 2010; Walters, 2011).

	<i>Positive characteristics of iPads</i>	<i>Educational uses of iPads</i>	
e-reader and ele	• Design of the device	• Presentation of class materials via multimedia systems (1)*	om features,
multimedia view	• Size and weight	• iPad provides access to multimedia databases and e-books (1)	the device.
Bansavich (201	• Multi-touch screen and interactivity	• Book in teachers pedagogical library (1)	setting, and
sciences (espec	• Long battery life	• Provides quick access to Apps that students might require for a particular learning task (1 to 7)	; of student
advising, lab se	• Speed of the device	• Students of all levels can use Apps, especially for reinforcement and rote learning of basic concepts (1)	of iPads at
the University (	• Relatively low cost	• Teachers can easily collect assignments (2)	on between
students and tea	• Low maintenance need	• Tool that allows teachers to easily experiment with technology (5)	heard to be
more motivated	• Portability	• A tool for creation, not just for consumption (6)	to be more
responsible in tl	• Easy to use	• iPad provides annotating and note taking features for meeting and classrooms (6, 7)	; rather than
purchasing phy	• Ease of connection to multimedia systems	• Supports learning engagement in variety of settings due to portability and fit-for-task suitability (1 to 7)	tially it is a
Although	• Instant on	• Supports different learning styles (1 to 6)	f an iPad is
new platform fo	• Quick transition between applications	• Kinesthetic and multi-touch interaction support students to develop visual and spatial skills (1 to 6)	an iPad can
that it is a creati	• E-reader and electronic textbook capabilities	• Students can achieve their learning goals faster with appropriate use of iPads (1 to 6)	technology.
be used as “boo	• Multimedia support and playback	• Students can achieve the level of “Create” at the peak of the Bloom’s taxonomy with appropriate use of iPads (1 to 6)	kinesthetic
Also, teachers	• Availability of Apps		reate” at the
interaction supp			
peak of the Blo			

* Related to an affordance listed in the last column of the Table 1

4. Teachers’ Private Theories

One of the limitations of the studies of affordances of mobile technology is that they are explored apart from teachers’ private theories that mediate adoption of this technology. Previous studies (e.g., Churchill, 2005) indicate that teachers’ use of technology is guided by a set of private theories.

The literature generally suggests that teachers hold cognitive constructs, beliefs, guiding principles, preconceptions or private theories, which determine their instructional decisions and technology integration. A variety of issues relevant to teachers’ private theories have been addressed in the literature, e.g., planning and teacher thinking when linking a curriculum to instruction (Clark & Peterson, 1984); teacher reflections and personal theories (Lloyd, 1999; Griffiths & Tann, 1992); teacher pedagogical content knowledge (Wilson, Shulman & Richert, 1987); teacher schemata and decision-making (Borko & Shavelson, 1990); teacher epistemology (Howard, McGee, Schwartz & Pursel, 2000); teacher beliefs, social dynamics and institutional culture (Windschitl & Sahl, 2002); and teacher thinking and instructional design practice (Moallem, 1998). Researchers have only recently begun to explore teachers’ use of technology and influences that shape their thinking and decisions (see Windschitl & Sahl, 2002; Churchill, 2005).

Previously, we conducted a study to investigate teachers’ private theories and their instructional technology use (see Churchill, 2005). Six areas of teachers’ private theories were identified to inform teachers’ technology use (see Table 2):

Table 2: Areas of teachers’ private theories (from Churchill, 2005)

<i>Area of private theories</i>	<i>Description</i>
• Students	• How students learn, their limitations, their ability to use technology for learning and collaboration
• Learning	• Knowledge and how is it acquired, useful teaching and learning strategies, ways learning can be evaluated
• Teacher	• Teachers’ roles in learning in a classroom and a technology-based environment
• Technology	• Use of technology in a class, ways in which technology-based learning differs from traditional classroom learning, limitations and benefits of technology for learning
• Design	• Selection criteria for topics determining suitability for technology-supported learning, how to plan and design an instructional unit
• Educational Changes	• Changes in society and their implications for education, ways in which such changes impact teachers and students and require uses of technology in education

5. The Study of Adoption of iPads

We are currently conducting a study that builds on the affordances of PDA technology and further explores iPad affordances as they emerge from classroom practitioners' efforts to understand and use this new technology in higher education. The following questions are central to the study:

- How are affordances of mobile technology utilized in context of uses of iPads?
- How teachers' private theories relate to adoption of affordances?
- How affordances lead to transformation in teachers' private theories?

The study utilizes the affordances summarized in Table 1 as an analytical framework for sorting data, and undergoes further analysis to understand adoption of affordances of mobile technology, and the ways in which the teachers' private theories (Table 2) mediate the use of this technology and transform through the process of adoption. The study is being conducted over an 18-month period. A group of nine teachers from different faculties from the University representing a range of disciplines from science, humanities and art is included in the study. A small sample of cases is sufficiently large for a qualitative study (see Savolainen, 1994; Small, 2009; Williams, 2000). Consistency technique is being used across the cases to allow comparability. The technique allows for limited uniqueness to be understood given that the participants are from a range of disciplines. The study employs multiple case study methodology to explicate affordances of TouchPads as they emerge from a sample of teachers from a single university and their efforts to use this technology. The study is an inductive, hypotheses-generating naturalistic inquiry, with the aim of accumulating an understanding and proposing recommendations relevant to the context of the study (Creswell, 1998; Flyvbjerg, 2006; Merriam, 1988; Yin, 1989). Its focus is on "the larger picture, the whole picture, and begins with a search for understanding of the whole" (Janesick, 2000, p.379), while allowing readers to draw their own conclusions (Stake, 2003).

The current stage of the study reveals certain patterns. The researchers developed patterns of private theories for each of the participants by interviewing them about a number of issues related to their teaching. Each of the participants has been provided by a new iPad device, giving them options to choose an iPad mini or a regular size device. All the participants opted to the regular device due to the size of a display area. Three sets of interviews were conducted up to this stage: one focusing on private theories upon beginning of the study, the second (group) interview, several months later after iPads have been received, focusing on initial impressions, apps downloaded and used, and the third interview at the beginning of current academic year focusing on the participants' plans for further uses, and any emerging issues. At the same time, effort has been made to collect any further data through a social networking site (Edmodo.com) set-up to allow reflections and sharing amongst the people involved in the research. The researchers examined Apps used by each of the participants, and developed a classification of these into emerging categories. The following group of tools emerged:

- Productivity Apps – These include tools such as word-processing, document annotation, creating of multimedia material tools. Specific Apps used include Mail, iAnnotate, Docs2PDF, Neu.Annotate, PDF Notes, Office2DH, iMovie and Dragon.
- Teaching Apps – These include tools that support classroom teaching, such as those that support connection to a projector, mark-book, presentation tools and classroom management tools. Examples of Apps used are Moodle, Clicker School, TeacherPal, Prezi Viewer, Slides Shark, LanSchool Teacher.
- Notes Apps – These are tools that enable note taking in combination with audio recording, drawing and typing. Examples of Apps are HansOn, Bamboo Paper, Penultimate, AudioNote, Draw Free and iPocketDraw.
- Communication Apps – These include tools that support communication and social networking. Some specific Apps include Facebook, Skype, Messages, FaceTime and MyPad.
- Drives – These include tools that allow connectivity to the Cloud, network drives and a computer. Some specific Apps include Air Shawing, FileBrowser, Dropbox, ZumoDrive, Air Drive and AirDisk.
- Blogging Apps – These tools allow convenient blogging via the iPad device. These Apps include Blogsy and Wordpress.
- Content Accessing Apps – These include tools such as e-books, multimedia material and video accessing tools. Some specific Apps include iBooks, Kindle, YouTube, Perfect Reader, iTunes and iTunesU.

Furthermore, attempt was made to link these categories of Apps to specific areas of private theories and affordances of mobile technology. This has been done by identifying links between the categories of Apps and categories of affordances through participant's private theories. Data from interviews and observations have been unitized and coded according to associations with three aspects: a Category of Apps, an Area of Private Theories, and an Affordance of Mobile Technology. The pattern of links presented in the Figure 1 was explicated in the study. The Figure shows links between areas private theories and Apps on one side, and the private theories and affordance of mobile technology on the other. The numbers on links between any two connections represents the number of participants whose data indicates such a link. For example, three participants associated 'Communication Apps' with their 'Private Theories about Students,' while seven participants associated 'Private Theories about Students' with 'Resources Environment' affordance. Purpose of opting for such summary statistics as a mean of cross-case analysis was to understand how adoption is taking place in general. Table 4 shows summary of connections between 'Categories of Apps used by the Participants,' 'Areas of the Participants' Private Theories,' and 'Affordances of Mobile Technology from Previous Studies.'

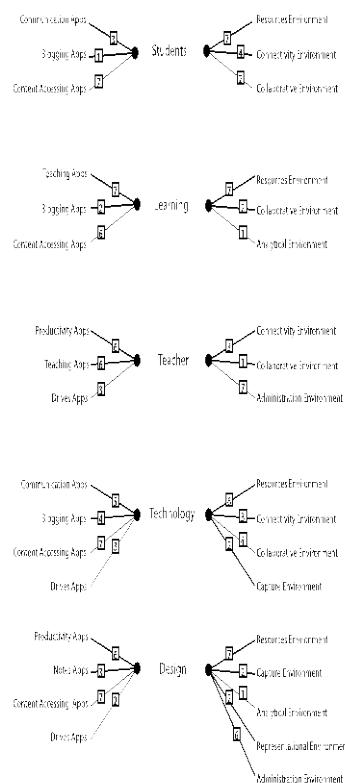


Figure 1. Connections between categories of Apps, private theories and affordances of mobile technology

Table 3: Summary of connections

<i>Categories of Apps used by the Participants</i>	<i>No. of Connections</i>	<i>Areas of the Participants' Private Theories</i>	<i>No. of Connections</i>	<i>Affordances of Mobile Technology from Previous Studies</i>	<i>No. of Connections</i>
Productivity Apps	6	Students	24	Resources Environment	34
Teaching Apps	13	Learning	25	Connectivity Environment	10
Notes Apps	3	Teacher	26	Collaborative Environment	9

Communication Apps	7	Technology	34	Capture Environment	4
Drives Apps	9	Design	36	Analytical Environment	2
Blogging Apps	6	~~Educational~~ Changes *		Representational Environment	2
Content Accessing Apps	27			Administration Environment	13
Total	71		145		74

*No data related to this area of private theories was analyzed

These results expose problematic nature of adoption of new technology by teachers. Previous study by Churchill (2005) inform that most desired outcomes in terms of embracing activity-base, student-centered pedagogy is achieved when teacher make their instructional planning decisions when driven by their private theories about 'Learning.' Driven by initial enthusiasm, we believed that iPad will have almost instant positive transformative effect on teachers, enabling them to more closely focus on uses of affordances to support their private theories about 'Learning,' and this will lead to more student-centered practices. However, on the contrary, the results show that this has not occurred, and the participating teachers were using iPads in a way that reflects traditional, teacher-centered approaches, where the technology was considered as a medium for transfer of knowledge, rather than as a set of tools that support learning through activities. The following are major observations:

- The most used category of Apps was Content Accessing Apps, while the most utilized affordance was Resources. This indicates inclination to adopt iPads as a medium for access to content materials such as web sites, Youtube videos, e-book, learning objects and readings.
- The most dominant theories are those about Design (planning of an instructional unit). Private Theories about Design most strongly related to Content Accessing Apps on one side, and Resources affordance on the other. Furthermore, Private Theories about Design strongly related to Productivity Apps on one side, and Administration affordance on the other. This shows that the participating teachers' instructional planning was strongly focusing on content, while there was a move to use certain productivity tools for administrative purpose during lesson planning.
- The second most dominant theories are about Technology. Private Theories about Technology most strongly related to Content Accessing Apps on one side, and Resources affordance on the other. Similarly to the previous observation, access to content resources played a central role. Focusing on technology has been documented in literature (see Churchill, 2005) to constrain teachers to not to give consideration to theories about learning.
- Private Theories about Students most strongly related to Content Accessing Apps and Resources affordance. Similarly, Private Theories about Learning most strongly related to Teaching and Content Accessing Apps on one side, and Resources affordance on the other. Content appears to dominate in both cases. This is problematic as it strongly indicates traditional, teacher-centered understanding of technology and education as a process of transmitting information.
- Private Theories about Teacher most strongly related to Teaching and Productivity Accessing Apps on one side, and Administration affordance on the other. This is a positive development and indicates that the participating teachers saw a lot of benefits of using iPad affordances to assist them in administrative tasks.

Strong focus on Content Accessing Apps and Resources affordances indicates that the participating teachers placed priority on an iPad to serve as a tool for access and delivery of information. What might be necessary is to engage teachers in exploring other possibilities of technologies, primarily those in which technology is used beyond delivery of resources, and serve as a tool for activities, support and evaluation, and where more emphasis is placed on collaboration, connectivity, representational possibilities and analytical uses.

Further data collection and analysis is expected to provide more in-depth understanding of connections between the affordances and private theories, and reveal areas of private theories that dominate the adoption of this technology over prolonged period of time. The researcher will attempt to understand any changes in private theories through uses of iPads and patterns of teacher change through such

experience, and contribute to articulation of a model for effective support for teachers and the application of TouchPad technology in higher education (with focus on more contemporary, student-centered teaching and learning). Study results will contribute to the articulation of specific recommendations to support teachers to transform their theories for effective utilization of affordances of iPad technology, and inform institutional planning to provide teachers with iPads or similar devices.

References

- ASTRI. (2010). *Support for e-learning catches media's attention*. Retrieved from http://www.astri.org/main/?contentnamespace=news_room:event:content:20090401rrx.
- Attewell, J. (2005). *Mobile technologies for learning*. London, UK: Learning and Skills Development Agency.
- Banister, B. (2010). Integrating the iPod Touch in K–12 Education: Visions and Vices. *Computers in the Schools*, 27(2), 121-131.
- Bansavich, J. C. (2011). *iPad study at USF*. Retrieved from <http://ipad.wiki.usfca.edu/file/view/iPad+Study+at+USF+Report.pdf>.
- Barnes, S. (2000). What does electronic conferencing afford distance education? *Distance Education*, 21(2), 236-247.
- Beebe, A. (2011). *iPads in the college composition classroom: A pilot program at the University of Texas at Tyler*. Retrieved from <http://conferences.cluteonline.com/index.php/IAC/2011NO/paper/view/177>.
- Borko, H. & Shavelson, R. J. (1990). Teacher decision making. In B.F. Joney & L. Idol (Eds.), *Dimensions of thinking and cognitive instructions*. (pp. 311-346). Hillside, New Jersey: Lawrence Erlbaum Associates.
- Brand, J. & Kinash, S. (2010). *Pad-agogy: A quasi-experimental and ethnographic pilot test of the iPad in a blended mobile learning environment*. Retrieved from <http://www.ascilite.org.au/conferences/sydney10/procs/Brand-concise.pdf>
- Catholic Education-Dioces of Paramatta. (2010). *iPad in schools: Use testing*. Retrieved from http://learningwithipads.blogspot.com/2011_04_01_archive.html.
- Chu, H.-C., Hwang, G.-J., Tsai, C.-C., & Tseng, C.-R. (2010). A two-tier test approach to developing location-aware mobile learning systems for natural science courses. *Computers & Education*, 55(4), 1618-1627.
- Churchill, D. (2005). Teachers' private theories and their design of technology-based learning. *British Journal of Educational Technology*, 37(4), 559-576.
- Churchill, D., & Churchill, N. (2008). Educational affordances of PDAs: a study of a teacher's exploration of this technology. *Computers & Education*, 50(4), 1439-1450.
- Churchill, D., & Hedberg, G. (2008). Learning object design considerations for small-screen handheld devices. *Computers & Education*, 50(3), 881-893.
- Churchill, D., Kennedy, D. M., Flint, D. & Cotton, N. (2010). Using handhelds to support students' outdoor educational activities. *International Journal of Continuing Engineering Education and Life-Long Learning*, 20(1), 54-72.
- Clark, M. C., & Peterson, L. P. (1984). *Teacher thought processes*. East Lansing, Michigan: The Institute for Research on Teaching.
- Clyde, L. A. (2004). M-learning. *Teacher Librarian*, 32(1), 45-46.
- Creswell, W. J. (1998). *Qualitative inquiry and research design: choosing among five traditions*. Thousand Oaks, CA: Sage Publications.
- Dwyer, D. C., Ringstaff, C., & Sandholtz, J. H. (1985-1998). *Apple Classroom of Tomorrow*. Cupertino, CA: Apple Computer Inc. Retrieved August 30, 2001 from <http://www.apple.com/education/k12/leadership/acot/library.html>.
- Education Bureau. (2010). *Working Group on Textbooks and E-learning Resources: Main Report*. Government of Hong Kong Special Administrative Region. Retrieved from http://www.edb.gov.hk/FileManager/EN/Content_689/wg%20final%20report.pdf.
- Flyvbjerg, B. (2006). Five Misunderstandings about case-study research, *Qualitative Inquiry*, 12(2), 219-245.
- Griffits, M., & Tann, S. (1992). Using reflective practice to link personal and public theories. *Journal of Education for Teachers*, 18(1), 69-84.

- Howard, B. C., McGee, S., Schwartz, N., & Pursel, S. (2000). The experience of constructivism: transforming teacher epistemology. *Journal of Research on Computing in Education* 32(4), 455-465.
- Hsieh, S.-W., Jang, Y.-R., Hwang, G.-J., & Chen, N.-S. (2011). Effects of teaching and learning styles on students' reflection levels for ubiquitous learning. *Computers & Education*, 57(1), 1194-1201.
- Janesick, V. J. (2000). The choreography of qualitative research design. In N.K. Denzin & Y.S. Lincoln (Eds.), *Handbook of qualitative research* (2nd Ed.) (pp. 379- 399). Thousand Oaks, CA: Sage Publications.
- Jennings, G., Anderson, T., Dorset, M., & Mitchell, J. (2011). *Report on the step forward iPad pilot project*. Retrieved August 22, 2011 from <http://bit.ly/1ddBoy>
- Jones, M., Buchanan, G., & Thimbleby, H. (2003). Improving web search on small screen devices. *Interacting with Computers*, 15(2003), 479-495.
- Kazi, S. A. (2005). *Vocatest: an intelligent tutoring system for vocabulary using mlearning approach*. Paper presented at the Redesigning Pedagogy: Research, Policy, Practice Conference, 30 May - 1 June 2005, Singapore.
- Kendall, K. E. (2010). Continually emerging technologies: will the iPad really change the way we live and work? *Decision Line*, 21(4), 11-13.
- Klopfer, E., & Squire, K. (2005). *Environmental detectives: the development of an augmented reality platform for environmental simulations*. Retrieved from <http://website.education.wisc.edu/kdsquire/manuscripts/ETRD-handheld-Draft.doc>.
- Liaw, S. S., Hatala, M., & Huang, H. M. (2010). Investigating acceptance toward mobile learning to assist individual knowledge management: based on activity theory approach. *Computers & Education*, 54(2), 446-454.
- Lincoln, S. Y., & Guba, G. E. (1985). *Naturalistic inquiry*. Beverly Hills, CA.: Sage Publications.
- Lloyd, J. M. (1999). *Knowledge and beliefs, roles, and guiding principles of two exemplary high school science teachers and a model for teacher reflection*. Unpublished doctoral dissertation, Virginia Commonwealth University, Richmond, Virginia.
- Lovat, T. J., & Smith, L. D. (1990). *Curriculum: action on reflection*. Wentworth Falls, NSW: Social Science Press.
- Luchini, K., Quintana, C., & Soloway, E. (2004). Design guidelines for learner-centered handheld tools. *CHI*, 6(1), 135-141.
- Merriam, B. S. (1988). *Case study research in education*. San Francisco: CA: Jossey-Bass.
- Moallem, M. (1998). An expert teacher's thinking and teaching and instructional design principles: An ethnographic study. *ETR&D* 46(2), 37-64.
- Murphy, G. D. (2011). Post-PC devices: A summary of early iPad technology adoption in tertiary environment. *e-Journal of Business Education & Scholarship of Teaching*, 5 (1), 18-32.
- Murphy, T. & Williams, C. (2011). The iPad as a class presentation platform. Retrieved from http://155.225.14.146/asee-se/proceedings/ASEE2011/Papers/FP2011mur183_199.PDF.
- New Media Consortium. (2011). The NMC Horizon Report: 2011 K-12 Education.
- Norman, D. A. (1988). *The psychology of everyday things*. New York: Basic Books.
- Ostashewski, N. & Reid, D. (2010). *iPod, iPhone, and now iPad: The evolution of multimedia access in a mobile teaching context*. In Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2010 (pp. 2862-2864). Chesapeake, VA: AACE.
- Patten, B., Sánchez, I.A., & Tangney, B. (2006). Designing collaborative, constructivist and contextual applications for handheld devices. *Computers & Education*, 46, 294-308.
- Pierson, E. M. (1999). *Technology integration practice as a function of pedagogical expertise*. Unpublished doctoral dissertation, Arizona State University, Arizona.
- Ratto, M., Shapiro, R. B., Truong, T. M., & Griswold, W. G. (2003). *The active class project: experiments in encouraging classroom participation*. Retrieved from <http://www-cse.ucsd.edu/~wgg/Abstracts/activeclass-cscl03.pdf>.
- Ray, B. (2002). PDAs in the classroom: integration strategies for K-12 educators. *International Journal of Educational Technology*, 3(1). Retrieved from <http://www.ao.uiuc.edu/ijet/v3n1/ray/index.html>.
- Roschelle, J., & Pea, R. (2002). A walk on the WILD side: How wireless handhelds may change CSCL. *International Journal of Cognition and Technology*, 1(1), 145-168.
- Savolainen, J. (1994). The rationality of drawing big conclusions based on small samples. *Social Forces*, 72, 1217-1224.

- Schömmmer, M. (1990). Effects of beliefs about the nature of knowledge and comprehension. *Journal of Educational Psychology*, 82, 498-504.
- Senge, M. P. (1990). *The fifth discipline: the art and practices of the learning organization*. London, UK: Century Business.
- Sharples, M. (2000). The design of personal mobile technologies for lifelong learning. *Computers & Education*, 34, 177-193.
- Sharples, M., Corlett, D., & Westmancott, O. (2002). The design and implementation of a mobile learning resource. *Personal and Ubiquitous Computing*, 6, 220-234.
- Small, M. (2009). How many cases do I need? On science and the logic of case selection in field-based research. *Ethnography*, 10(1), 5-38.
- So, K. K. T. (2004). Applying wireless technology in field trips: A Hong Kong experience. *Australian Educational Computing*, 19(2). Retrieved from [http://www.cite.hku.hk/people/tkkso/Publications/2004/Applying%20Wireless%](http://www.cite.hku.hk/people/tkkso/Publications/2004/Applying%20Wireless%20Technology%20in%20Field%20Trips%20-%20A%20Hong%20Kong%20Experience.pdf)
- Song, Y., & Fox, R. (2008). Affordances of PDAs: undergraduate student perceptions. *The Journal of the Research Center for Educational Technology*, 4(1), 19-38.
- Stake, R. (2003). Case studies. In N. K. Denzin & Y. S. Lincoln (Eds.), *Strategies of qualitative inquiry* (2nd Ed.) (pp. 134 - 164). Thousand Oaks, CA: Sage.
- Telecomasia. (2010). *iPad sales hit 2m in under two months*. Retrieved from <http://www.telecomasia.net/content/ipad-sales-hit-2m-under-two-months>.
- Walters, E. A. (2011). *Will the iPad revolutionize education?* Retrieved from http://www.iste.org/Libraries/Leading_and_Learning_Docs/May-2011-Point-Counterpoint.sflb.ashx.
- Heral Sun. (2011). *Tablet computer ownership is highest in Hong Kong*. Retrieved from <http://www.heraldsun.com.au/technology/tablets/tablet-computer-ownership-is-highest-in-hong-kong/story-fn5qlb5w-1226102678709>
- Williams, M. (2000). Interpretivism and generalization. *Sociology*, 34(2), 209-224.
- Wilson, M. S., Shulman, S. L., & Richert, E. A. (1987). '150 different ways' of knowing: representations of knowledge in teaching. In J. Calderhead (Ed.), *Exploring teachers' thinking* (pp. 104-124). London, UK: Cassell Educational Ltd.
- Windschitl M., & Sahl, K. (2002). Tracing teachers' use of technology in a laptop computer school: The interplay of teacher beliefs, social dynamics, and institutional culture. *American Educational Research Journal* 39, 1, 165-205.
- Yin, R. K. (1989). *Case study research: design and methods*. Newbury Park, CA: Sage Publications.
- Yinger, J. R. (1978). *A study of teacher planning: description and model of preactive decision making*. East Lansing, Michigan: The Institute for Research on Teaching.
- Zurita, G., & Nussbaum, M. (2004). Computer supported collaborative learning using wirelessly interconnected handheld computers. *Computers & Education*, 42, 289-314.

Improving student engagement through a blended teaching method using Moodle

Richard LAI*, Nurazlina SANUSI

*Department of Computer Science and Computer Engineering
La Trobe University, Victoria 3086, Australia*

*R.Lai@latrobe.edu.au

Abstract: Web-based learning system commonly known as Learning Management System (LMS) which makes use of internet technologies has been widely used by many education institutions around the globe. LMS forms a part of their campus-based and distance teaching. With the wide uses of LMS nowadays, university teaching is often conducted in blended mode: partly through face-to-face teaching and partly through LMS. To date, little research has been carried out to investigate to what extent the uses of LMS contribute to student learning, particularly student engagement. In this paper, we present a blended teaching method for promoting better student engagement and their willingness to participate in the learning activities through better uses of LMS (Moodle in our case), the design of our assessments, and the ways we lead them to learn. To demonstrate the usefulness of our method, we also present in this paper the results of applying it to teaching a third year computer science subject, CSE3MQR.

Keywords: Student Engagement, Blended Teaching, Moodles, Constructive Alignment, Constructive Progressive Alignment

1. Introduction

The history of the application of computers to education has started since 1950s. Learning systems have progressed from in-house built systems to commercial ones. The progress is inherently tied up to the use of computer networked technologies and applications in supporting the distance learning or in the classrooms. The applications of computers evolved and give new ways of delivering educational programs. Many scholars have adopted the integration of computer application for teaching and learning as “e-Learning system” which is used interchangeably with different acronyms such as “learning management system (LMS)”. E-learning systems are used to describe educational computer applications that handle all aspects of the learning process, allowing students’ to managing learning material content and also providing educators to find ways with flexible teaching and learning environment for campus-based students and fully online courses institutions (Coates et al 2005; Govindasamy et al, 2002). LMS such as BlackBoard, WebCT, Moodle etc. are not only tools to support e-learning in teaching and learning but also provided opportunities for self-regulated learning and supporting collaborative learning (Paechter et al 2010). Higher education institutions have responded by offering LMS as a part of everyday experience in campus-based and distance learning of teaching and learning. Despite the acceptance of LMS amongst students in higher institutions, it does not always deliver on its promise that they will receive the maximum benefit from their learning.

Research into the use of LMS mainly investigates students’ perceptions of their learning regarding e-learning system's effectiveness. Several new technologies such as mobile computing, ubiquitous computing, ontology engineering, semantic web, grid computing, XML services have offered a kind of flexible educational platform for e-learning systems. However, highly used of teaching technologies may not lead to a significant effect of understanding in students’ learning although it does support learning in an innovative ways as teaching technologies make a vast difference in traditional teaching method and led to enhance students’ experience of learning. Neither technology-centered nor methodology-centered

approaches can guarantee the success and the practical applicability of learning environments. Prior studies have shown that student's learning experience is an indicator of attitudes satisfaction towards the integration of e-learning systems in learning (Dawson et al 2010; Liaw 2008].

A study focus on student's perceptions with online delivery using a constructivist approach to learning is conducted by Hughes et al (2002). In their study, 220 students participated in an evaluation of online delivery. A qualitative techniques of analysis resulted that learning with web-based environment swept the students' ICT anxiety and improve their interest in learning. They conclude that the study did not successfully developed the constructivist approach but online method can be proven to be a very useful tool in improving the student's ability in learning.

LMS has been widely used by many education institutions around the globe. LMS forms a part of their campus-based and distance teaching. With the wide uses of LMS nowadays, university teaching is often conducted in blended mode (Garrison et al 2004): partly through face-to-face teaching and partly through LMS. To date, little research has been carried out to investigate to what extent the uses of LMS contribute to student learning, particularly student engagement. In this paper, we present a blended teaching method for promoting better student engagement and their willingness to participate in the learning activities through better uses of LMS (Moodle in our case), the design of our assessments, and the ways we lead them to learn. To demonstrate the usefulness of our method, we also present in this paper the results of applying it to teaching a third year computer science subject, CSE3MQR (Metrics, Quality and Reliability).

2. Moodle

La Trobe has been using Moodle as the LMS for teaching and learning since 2011. Moodle (Modular Object-Oriented Dynamic Learning Environment) is an Open Source Course Management System (CMS), also known as a Learning Management System (LMS) (<http://moodle.org>). It has become very popular among educators around the world as a tool for creating online dynamic web sites for their students. Moodle aims to give educators good tools to manage and promote learning, but there are many ways to use it. For instances, it has features that allow it to scale to very large deployments and hundreds of thousands of students, yet it can also be used for a primary school or an education hobbyist. Many institutions use it as their platform to conduct fully online courses, while some use it simply to augment face-to-face courses (known as blended learning). Many users love to use the activity modules (such as forums, databases and wikis) to build richly collaborative communities of learning around their subject matter (in the social constructionist tradition), while others prefer to use Moodle as a way to deliver content to students and assess learning using assignments or quizzes.

3. The Blended teaching method

Constructive Alignment (CA) (Biggs 1996, 1999, 2003) forms is a popular pedagogy adopted in many universities in the world. "Constructive" refers to the principle of constructivism in learning which states that meaning is personal, it depends on motives, intentions, prior knowledge, etc., and learning is a way of interacting with the world; and "Alignment" refers to what a lecturer does to support the appropriate learning activities in order to achieve the intended learning outcomes. Lecturers are responsible to facilitate the learning activities of the students and design the assessment tasks which assess students' Intended Learning Outcomes (ILOs).

CA is largely a technique for teaching planning; and its focus is on how the teaching activities enable students achieve the Intended Learning Outcomes (ILO) of a subject. However, CA does not pay much attention to the progressive learning behaviours of students, which influence what they would do for learning. With CA, ILOs could be measured towards the end of the teaching period, typically by examination and a big assignment; and students might view them as urgent and resort to outside help. We have developed a new pedagogy called Constructive Progressive Alignment (CPA) (Lai and Sanusi 2013), an extension to the CA system, which also considers students' progressive learning behaviours when planning the teaching activities. The meaning of "Constructive" and "Alignment" remain the same as in the CA context. "Progressive Alignment" means that a lecturer designs teaching activities that support students' progressive learning behaviours as well as their abilities to achieve the ILOs. With CPA, the ILOs

are specified using the SOLO taxonomy (Biggs and Collis 1982) and the strategy for achieving students' progression in learning is based on Shulman's table of learning (2002).

Shulman's table of learning (2002) defines a six-stage learning process. Which consists of: (1) Engagement and Motivation; (2) Knowledge and Understanding; (3) Performance and Action; (4) Reflection and Critique; (5) Judgment and Design; and (6) Commitment and Identity. However, stages 5 and 6 refer to students' longer and life-long learning. We are of the opinion that we could improve higher education student learning if we just focus on the first four stages of Shulman's table of learning, given the fact that there are only a limited number of weeks in one semester for teaching a subject. At La Trobe University, there are 12 weeks of teaching in one semester. We use a blended teaching method with the use of Moodle. The designs of the teaching and learning activities are centred around Shulman's first four stages of learning so that we have confidence that students are learning from stage to stage; and consequently, they will increase their learning.

4. Teaching activities for enhancing student engagement

Learning begins with student engagement, without which subsequent stages of learning will not succeed well. We find out students' learning preferences so that we could align our ways of teaching with students' learning styles. To obtain such information from the students, we conduct a Moodle online survey amongst them at the start of a semester. The survey was entitled "Approach to Studying XXX" (where XXX is the name of the subject) and used a five-point Likert-type scale (with 5 being the most true and 1 being the least true), which indicate the degrees to which the students agree with a certain study style or behaviour. It is aimed at gaining some ideas about what made the students engage in learning and what motivated them to study, based on their past experiences in learning activities.

The survey consists of 15 questionnaires; some examples are: (i) I prefer a personalized approach to learning and want to have peer learning with my classmates; (ii) I am able to do the best when learning the practical aspects of subject; and (iii) I like a clearly defined schedule and standards so I know what to do rather than taking independent action. Students indicated their level of agreement by selecting a number within the range from one to five, with five meaning the highest level of agreement. The results are published on Moodle and discussions are held with the students to arrive at joint decisions on the breakdown of assessment and styles of learning and teaching etc.

To obtain further feedbacks from them at the start of the semester, we briefly explain the topics of the subject to be taught. We also conduct a Moodle survey which enables them to indicate their levels of interest in each of these topics. Further, the survey also consisted of the following two questions: (i) I like to have as many topics as possible to be covered in this course, with the understanding that each of the topics will not be taught in depth; and (ii) I like to have a lesser number of topics to be covered but at a greater depth. Students indicate their level of interest/agreement by selecting a number within the range from one to five, with five meaning the highest level of interest/agreement. To promote student engagement, we concentrate our teaching more on their preferred topics.

At La Trobe, examination usually constitutes between 70% to 80% and assignment 20% to 30% of the assessment marks. For the CSE3MQR, it is 60% for examination and 40% for course work. The bigger percentage for course work is to encourage students to be more engaged in learning and to perform more learning activities themselves. All assessment tasks were conducted 100% on Moodle; that is there is absolutely no pen and paper submission. In this way, students are more engaged in their learning as the young people today are living and "sleeping" with the laptops and smart phones. The e-Assessment tasks are of smaller sizes and distributed weekly. Typically, students were given one or two weeks to complete a task; for instance, quiz is due at 9am on each Monday; tutorial is at 9am on each Tuesday; laboratory at 9am on a Wednesday, and problem solving question is due at 9am on Thursday. The regularity get them into the habit of reviewing the teaching materials, thus engaging them in learning.

The e-Assessment tasks are of different types and aim to enhance their engagement in learning as it is in general human beings like varieties and tend to get bored with just one thing quickly. The assessment tasks were to be of different varieties, eg, quizzes, problem solving tasks, essay, tutorial questions, laboratory

questions, assignment requiring researching into commercial/industrial issues. The marking guidelines are made explicitly to students; they are marked according to two main criteria: (a) evidence of effort; and (b) correctness; students will get full marks for a question which demonstrates these two criteria. Each e-Assessment task is designed for students to learning a particular aspect of the subject.

We sent out weekly Moodle announcements reminding them about e-Assessment deadline, marking criteria, the availability of assessment results, general feedbacks on the assessment tasks, seminars and talks on topics that are relevant to them, what would be taught in the next lecture, and what would be done in the next laboratory/tutorial class.

Practitioners from the computer industry are invited to give a guest lecture. The aim is to bring the real world into the class room. To increase student learning and engagement, it is essential that they see how things are put into perspective with the industry and they are able to see the relationship between their career, the industry and currently what they are learning.

5. Implementing the method

We have applied our method to teaching a few computer science subjects since 2011. One of them was CSE3MQR (Metrics, Quality and reliability). In this paper, we limit our discussions on our experiences in using the method to teach CSE3MQR in 2012. CSE3MQR is a subject of the Bachelor of Software Engineering (BSE) course. A third year students has to complete the studies of subjects totaling 120 credit points. CSE3MQR is worth 15 credit points. This subject examines the different attributes of the quality of a piece of software and their meanings. The topics covered include the use of metrics to improve software quality, different types of metrics, software complexity, size estimation, Goal Question and Metrics (GQM), software reliability concepts, reliability model, reliability estimation, testing issues in the real world, test suite design, testing techniques, management issues in testing, and software release policies. In 2012, there were 35 students who enrolled in CSE3MQR. Teaching consisted of two one-hour lectures and one two-hour laboratory/tutorial.

6. Student Engagement Experience Questionnaires and results

We have received an approval from the Ethics committee of La Trobe University to conduct a survey amongst the CSE3MQR students about their learning experiences. The approval number is FHEC11/R49. A survey form was constructed to find out the learning experiences of the 2012 MQR students. The survey form was handed out to the CSE3MQR students during the laboratory/tutorial class of the last week of the semester. Students were asked to select one of the following against each of the questions: (i) SA- Strongly Agree (represented by a score of 5); (ii) A - Agree (represented by a score of 4); (iii) N - Neutral (represented by a score of 3); (iv) D - Disagree (represented by a score of 2); and (v) SD - Strongly Disagree (represented by a score of 1)

In order to preserve the integrity of the data and the data collection process, the forms were collected by another academic staff (suppose Joe was his name) rather than the lecturer. Joe collected all the forms and put them in an envelope in his office. He then stamped on each of the survey forms a departmental chop with his signature and the date of the signature. When we were ready to do the analysis, we worked only on the signed and stamped survey forms. There were 35 students who enrolled in CSE3MQR in 2012; and there were 27 students who participated in the survey. The statistical data were used to examine the students' opinions on the effectiveness of the teaching method with the aim of improving their learning. The summary can be found in Table 1, with AS meaning Average Score. After the end of the semester, the CSE3MQR students were interviewed. Some student interview sample data appear in Table 2

Table 1: Summary of Students' responses to the questionnaires on "Engagement and Motivation"

Engagement and Motivation questionnaire	SA	A	N	D	SD	AS
1. I think doing a variety of the smaller e-Assessment tasks has motivated me to learn the subject materials better, as compared to doing one big assignment.	14	11	1	1	0	4.4

2. I think doing the e-Assessment tasks has helped me engage more on this subject, as compared to using pen and paper.	10	13	3	1	0	4.2
3. Suppose I miss the deadline of an e-Assessment submission and know that a late submission will attract a deduction in marks. I still like to submit it because the e-Assessment tasks of this subject in general motivate me to learn the materials better.	13	9	3	1	1	4.2
4. The fact that the lecturer of this subject gave weekly online announcements about assessment, tutorial/laboratory, marking criteria, seminar and talk, assessment results, etc., has helped me organize my studies better.	16	5	4	1	1	4.3
5. The fact that the lecturer considered our opinions on the breakdown of the marks of the e-Assessment tasks has motivated me to learn and engage more in this subject.	9	14	4	0	0	4.3
6. The fact that the lecturer taught and concentrated on the topics of our preferences has motivated me to learn and engage more in this subject.	12	8	6	1	0	4.0
7. The fact that the lecturer invited his past students to give guest lectures on their work experiences and knowledge and how this subject has helped them in their career has motivated to learn more about the subject material.	11	8	5	3	0	4.0
8. The fact that the course work of this subject constitutes a bigger percentage (40% as compared to the normal 20% or 30%) of the total assessment has motivated me to engage more in the subject.	17	7	2	1	0	4.5

Table 2: Students' Learning experiences in "Engagement and Motivation"

Sample answer to each of the above 8 questionnaires on Engagement and Motivation	
1. Smaller and regular e-assessment tasks motivated me to learn because it is easier to learn by doing a smaller assignment as compared to one big assignment.	
2. E-assessment motivated me to learn more because I found it easier to do my assignment using my computer. I am attached to my computer.	
3. I still want to submit the tasks after deadlines because I do not miss my marks even though I know there is a penalty for it. But still I want to submit because I want to learn.	
4. Weekly online announcements motivated me to learn because it helped me organize things and it served as a good reminder for me to learn the subject.	
5. The fact that the lecturer took into account students' opinion on the breakdown of the marks had motivated me because I felt involved in the learning process.	
6. The fact that the lecturer taught the topics of my preferences motivated me to learn because the interesting topics made me want to come to the class.	
7. Guest lectures are good. Because it motivates me and helped me to get the direction for my career.	
8. The percentage of 60% and 40% is good because I know I can get better marks in the assignment and I feel secured.	

7. Conclusions

Sheard et al [2010] reported that poor student attendance in the Australian university classrooms is a norm, and that it is perceived that there is a lack of engagement in learning by students. The new kind of students have thus created a need for universities to think of new ways of engaging students in learning. With the wide uses of Learning Management Systems (LMS) nowadays, university teaching is often conducted in blended mode: partly through face-to-face teaching and partly through LMS. We are of the opinion that the problem of poor class attendance will persist due to the facts that students are busy with their lives. In this paper, we have presented some strategies as to how we can promote better student engagement and their willingness to participate in the learning activities through better uses of LMS (Moodle in our case) , the

design of our assessments, and the ways we lead them to learn. We have applied these strategies to teaching a few computer science subjects; and in this paper we have presented the learning experience in student engagement of the 2012 CSE3MQR class; and the results are encouraging.

Laurillard (2002) stated that instructional designers should drive eLearning, not technologists and those who are innovative educators will be those who maximise eLearning and ensure its further development. Ravenscroft (2001) argues that “we cannot truly transform educational practice for the better through using new technologies unless we examine the roles the computer can play in truly stimulating, supporting and favouring innovative learning interactions that are linked to conceptual development and improvements in understanding.” Future progress in eLearning will come from a better understanding of the dynamics of teaching and learning and not from more improved or functional technology, though as mentioned the latter does provide opportunities for new, innovative pedagogies to develop. It is concluded that our work is based in innovative teaching practices rather than breakthrough in technologies which provides opportunities for the former and that we have presented results that support the arguments of the above researchers.

References

- Biggs, J. (1996), Enhancing teaching through constructive alignment, *Higher education*, 32, pp.347-364
- Biggs, J. (1999), What the Student Does: teaching for enhanced learning, *Higher Education Research and Development*, 18(1), pp.57-75
- Biggs, J. (2003), Aligning teaching and assessing to course objectives, *Teaching and Learning in Higher Education: new Trends and Innovations*
- Biggs, J., and Collis, K. (1982) Evaluating the Quality of Learning: The SOLO Taxonomy (New York: Academic Press.
- Dawson Shane, Heathcote Liz, Poole Gary, 2010. Harnessing ICT potential: The adoption and analysis of ICT systems for enhancing the student learning experience, *International Journal of Educational Management*, 24, pp.116-128
- Dernitl, M., and Pitrik, R.M. (2005). The role of structure, patterns and people in blended learning, *The Internet and Higher Education*, 8(2), pp.111-130.
- Coates,H., James,R., Baldwin,G. (2005). A critical examination on the effects of learning management systems on university teaching and learning, *Tertiary Education and Management*, 11, pp.19-36
- Govindasamy,T. (2002). Successful Implementation of e-Learning: Pedagogical Considerations, *Internet and Higher Education*, 4, pp. 287-299
- Garrison, D.R., and Kanuka, H. (2004). Blended learning: Uncovering its transformative potential in higher education. *The Internet and Higher Education*, 7(2), pp.95-105.
- Hughes, M., Daykin,N.,2002. Towards Constructivism: Investigating Students' Perceptions and Learning as a Result of Using an Online Environment, *Innovations in Education and Teaching International*,39(2),pp.217-224
- Lai, R., and Sanusi, N (2013). Improving higher education student learning through a table of learning, *Special issue on Higher Education in Creative Education*, July 2013.
- Laurillard, D. (2002). Design tools for eLearning. *Keynote address at the 19th Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education (ASCILITE)*, December 6-8, 2002, Auckland, New Zealand.
- Liaw, Shu-Seng, (2008). Investigating students' perceived satisfaction, behavioral intention, and effectiveness of e-learning: A case study of the Blackboard system', *Computers & Education*, 51, pp.864-873
- Paechter M., Maier, B.,Macher, D. (2010). Online or face-to-face? Students' experiences and preferences in e-learning. *Computers & Education*, 13, pp.292-297
- Ravenscroft, A. (2001). Designing E-learning Interactions in the 21st Century: revisiting and rethinking the role of theory. *European Journal of Education*, 36 (2), 133-156.
- Sheard, J., Carbone, J., Hurst, A.J. (2010). Student engagement in first year of an ICT degree: staff and student perceptions, *Computer Science Education*, 20(1), pp.1-16.
- Schulman, L. S. (2002). Making differences: a table of learning. *Change* 34, 36-44., 2002.

Embedding Collaboration into a Game with a Self-explanation Design for Science Learning

Chung-Yuan HSU^{a*}, Feng-Chin CHU & Hung-Yuan WANG^b

^a*Department of Child Care, National Pingtung University of Science and Technology, Taiwan*

^b*Graduate Institute of Applied Science and Technology, National Taiwan University of Science and Technology, Taiwan*

*jackohio@mail.npust.edu.tw

Abstract: The purpose of this study was to examine the impacts of embedding collaboration into a game with a self-explanation design on supporting the acquisition of light and shadow concepts. The participants were 184 fourth graders who were randomly assigned to three conditions: a solitary mode of the game with self-explanation, a collaborative mode with self-explanation, or the control condition of a single-user game without integrated self-explanation. Students' conceptual understanding was measured through an immediate posttest and a retention test with a three-week delay. The findings showed that having students collaboratively or solitarily play science-based games embedded with a self-explanation design is not sufficient to help them learn science concepts. Rather, it was the level of engagement in responding to the self-explanation prompts that mattered.

Keywords: Game-based learning, self-explanation, science learning, multiplayer game

1. Introduction

The call to embed instructional principles into digital games (hereafter named games) for science learning has been receiving growing attention in recent years. If designed well, games can successfully help learners articulate and relate their understandings to more explicit structures (Clark & Martinez-Garza, 2012). Researchers (Hsu, Tsai, & Liang, 2011) have suggested that pedagogy plays an essential role in determining the success of game-based learning. Among the pool of pedagogy, self-explanation is one of the effective approaches to stimulating the development of deeper understanding. Roy and Chi (2005) indicated that learning is enhanced when learners are engaged in or are prompted to generate explanations to themselves during an activity. Through the process of self-explaining, a linkage is built up between the newly learned materials and prior knowledge (Chi, De Leeuw, Chiu, & LaVancher, 1994). The results of previous studies have identified that integration of the self-explanation principle into a game environment can facilitate students' construction of science concepts. In Johnson and Mayer's (2010) study, they found that students who played a Circuit Game with self-explanation prompts outperformed than those who played the game without any prompts. In addition to self-explanation, collaboration in game play is also an ideal approach to not only allow students to help one another and assume responsibility for their success or failure (Zea, Sánchez, Gutiérrez, Cabrera, & Paderewski, 2009), but also to promote students' learning attitude and motivation (Sung & Huang, 2013), as well as engaging players in active participation. Meanwhile, Nelson (2007) pointed out that a collaborative game context enables players to form an understanding in partnership with peers, which can enhance their individual comprehension through guidance from the group.

An engaged player enthusiastically keeps playing and focuses on the game tasks over time, which is an essential part of the learning progress. The previous research (Hsu, Tsai, & Wang, 2012) has suggested that the level of engagement plays an essential role in the effectiveness of a game embedded with a self-explanation design. That is, while responding to the prompts, the players who showed high engagement outperformed those who had low engagement and those who were in control groups. Based on the findings, this study intended to integrate the collaboration approach into the self-explanation game design for enhancing the players' engagement and learning outcomes. An experiment has been

conducted to evaluate the effectiveness of the proposed approach via investigating the following research questions:

1. What were the impacts of embedding collaboration into a game with a self-explanation design on supporting the acquisition of light and shadow concepts?
2. Did the participants' engagement in answering the self-explanation prompts influence their learning outcomes?

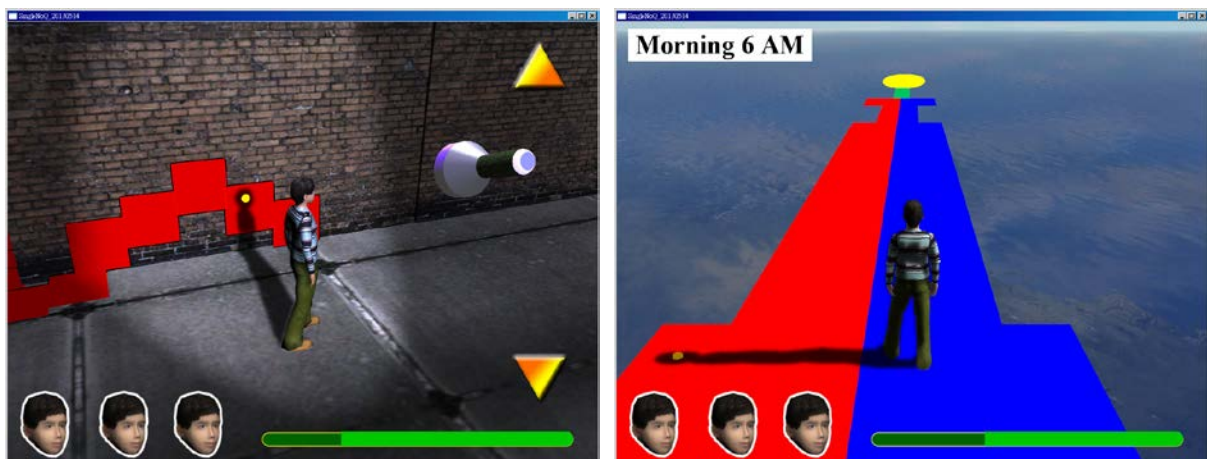
2. Methodology

Participants

The participants were 184 fourth graders (77 females and 107 males) recruited from an elementary school in southern Taiwan. They were randomly assigned into three groups: experimental group 1 (playing a single-user game embedded with self-explanation, hereafter named experimental 1), experimental group 2 (playing a multi-user game embedded with self-explanation, hereafter named experimental 2), and the control group (playing a single-user game without integrated self-explanation). There were 44, 96, and 44 participants in these groups, respectively.

Materials

Participants played “*Saving the Princess*,” a game developed in this study to facilitate the fourth graders' acquisition of light and shadow concepts. The subject content was drawn from their textbooks and adhered to the national curriculum standards for science in Taiwan (Ministry of Education, 2008). The game consists of three stages, each of which delivers a core concept, for instance, the relationship between the height of a light source and the length of the shadow produced, shadow changes in a day, and shadow intensity. In the first stage, the game rules required that the player constantly adjust the height of a flashlight so as to control the length of the avatar's shadow within the restricted area (see Picture A in Figure 1). The game rules of the second stage need the player to either move around or pause in order to keep the avatar's shadow within the floor during the changing time (see Picture B in Figure 1). The last stage is similar to the second one, except for a more complex floor and adding changing weather. A time limitation of four and a half minutes was imposed on each of the three stages of the game. Every player has to pass through the three stages within 35 minutes. If they fail, they are directed to the posttest.



A. Screenshot of stage 1

B. Screenshot of stage 2

Figure 1. Screenshots of the game, *Saving the Princess*.

The game has three versions, a basic version for the control group, a self-explanation version for experimental 1, and a self-explanation with collaboration version for experimental 2. These versions share the same features, except that the self-explanation version of the game offers a multiple-choice question as a self-explanation prompt and the collaboration version allows two players to co-play in the game context. A self-explanation prompt appears whenever a mistake is made during game playing. The prompt includes three options, one of which accurately explains the cause of the failure. Take Stage 1 for example; the options are: 1) I adjusted the position of the flashlight too high; 2) I adjusted the position of the flashlight too low; and 3) I have no idea. The game does not continue until one of these options is selected. Students in a collaborative mode played the game with a peer. Neither of them knew who their partner was or where she or he was situated. When either one of the players made a mistake while playing, they both had to stop playing and respond to the prompt (see Figure 2). If one failed the prompt, his or her partner's screen would show the occurrence of the failure and required him or her to choose an option as a suggestion within one minute. Finally, the player who made a mistake would receive a suggestion from the partner.

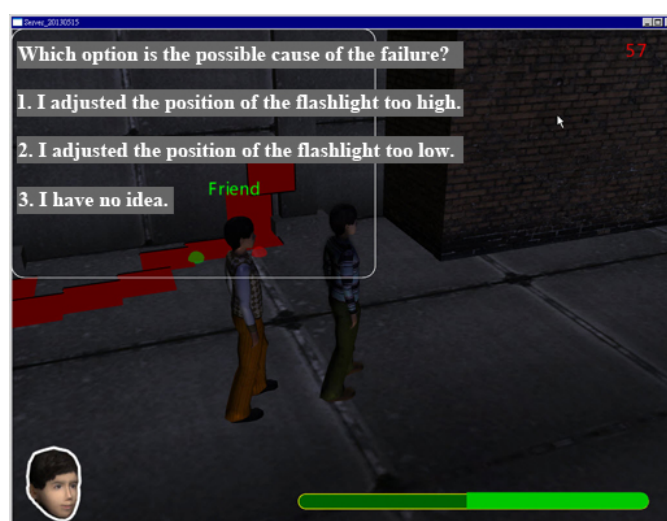


Figure 2. Screenshot of collaboratively responding to the prompt.

Measurement

The participants' learning outcomes were measured by a posttest and a retention test. The former was administered right after the treatment, while the latter was administered three weeks later. Both tests shared the same 10 multiple-choice questions that merely varied in the order of displaying the questions and options. The sample items include: "How does the shadow length change when the light keeps moving upward?" and "How does the shadow intensity change when fog appears?" Each question item of each test was counted as one point so that the maximum score was ten points.

Procedure and data analysis

Before the start of the game, the participants received a random assignment of three conditions (experimental 1, experimental 2, and control). The researchers helped those in experimental 2 build up an online connection with their partners, but they did not know who their partners were. Next, all the students received a brief introduction of the study and played *Saving the Princess*. During the game playing, they were told to remain silent and raise a hand if they had any questions. A posttest was given when the players had either completed the three stages of the game or after the required time of 35 minutes. No time limitation was imposed on taking the posttest or the retention test.

The participants selected for analysis were those who had played Stage 3 of the game during the treatment, which ensures that every player had experienced the core concepts the game was designed to

instruct. Among a total of 184 students, 153 (61 females and 92 males) were chosen, of whom 40, 42, and 71 respectively were in experimental 1, experimental 2, and the control group. To examine the impacts of integrating self-explanation into a multi-user game on supporting the acquisition of light and shadow concepts, an analysis of variance (ANOVA) was used to compare the group differences in the posttest and retention tests. To examine whether the participants' engagement in answering the self-explanation prompts influenced their learning outcomes, an analysis of variance was used to compare the group differences in the posttest and retention test. The players' engagement was categorized into high and low. The high engagement group represents those whose correct responses are greater than the sum of their incorrect and unknown responses, whereas the low engagement group refers to those whose correct responses are fewer than their incorrect responses together with their unknown responses. That is, if one responded to 10 prompts with 3 correct, 5 incorrect, and 2 unknown responses, then that player would be classified into the low engagement group.

3. Results

Does the multi-user game embedded self-explanation affect learning outcomes?

The participants' scores of the posttest and 3-week retention test are displayed in Table 1. As shown, except for five students who failed to take the retention test, a total of 153 students who at least entered the third stage of the game were analyzed. The ANOVA results identified a statistically significant difference in the posttest scores ($F = 3.44$, $p < 0.05$). The post hoc test (Fisher's least significant difference, LSD) suggests that while playing the game embedded with the self-explanation design, the participants who played the single-player mode, rather than the collaborative mode, outperformed those of experimental 2 and the control group. However, after a delay of three weeks, no statistically significant difference was found by an ANOVA test. This finding implies that no difference in learning outcomes was identified when the students played the game with or without self-explanation as well as with or without peers.

Table 1: Comparisons of the posttest and retention scores within groups.

Test	Group	N	Mean	SD	F	Post hoc tests
Posttest	(1) Experimental 1 (Single)	42	7.95	1.75	3.44*	(1) > (2); (1) > (3)
	(2) Experimental 2 (Collaborative)	71	6.99	2.07		
	(3) Control	40	7.05	2.08		
Retention	(1) Experimental 1 (Single)	42	7.38	2.10	0.17	
	(2) Experimental 2 (Collaborative)	71	7.28	2.15		
	(3) Control	40	7.13	1.65		

Did the participants' engagement in answering the self-explanation prompts influence their learning outcomes?

As described in the data analysis section, each student's engagement in the experimental groups was categorized into either a high or low engagement group according to their responses to the prompts. A total of five groups were displayed, which are experimental 1 (high), experimental 1 (low), experimental 2 (high), experimental 2 (low), and the control group. Table 2 displays the results of ANOVAs with post hoc comparisons of students' posttest and retention test scores among these groups. As shown, a statistically significant difference was identified in the posttest ($F = 2.49$, $p < 0.05$). The post hoc comparisons indicate that students in the experimental 1 (high) group performed better than those in the experimental 2 (low) and control groups. That is, while playing the game embedded with self-explanation prompts, individual players who concentrated on answering the prompts tended to perform better on the immediate test than those who carelessly played with a peer or who were in the control group.

Furthermore, a statistically significant difference was found in the retention test ($F = 4.33, p < 0.01$). As shown in Table 2, both the experimental 1 (high) and experimental 2 (high) groups outperformed the experimental 1 (low), experimental 2 (low), and control groups. This finding reveals that those who engaged in answering the prompts as well as those who engaged in answering the prompts and helping their peers with the prompts were inclined to have better performance than those who did not or who were in the control group. Of particular note is the fact that when it comes to integrating collaboration into a game with a self-explanation design, the effectiveness may not become significant until after a period of time (e.g., a three-week delay in the present study).

Table 2: Comparisons of the posttest and retention scores within groups of different levels of engagement.

	Posttest			Retention test		
	N	Mean	SD	N	Mean	SD
(1) Experimental 1 (High)	16	8.50	1.10	16	8.38	1.46
(2) Experimental 1 (Low)	26	7.62	2.00	26	6.77	2.22
(3) Experimental 2 (High)	28	7.29	2.31	28	8.18	1.74
(4) Experimental 2 (Low)	43	6.79	1.90	43	6.70	2.21
(5) Control	40	7.05	2.08	40	7.13	1.65
<i>F</i>	2.49*			4.33**		
<i>Post hoc</i>	(1) > (4)*; (1) > (5)**			(1) > (2)*; (1) > (4)*; (1) > (5)**; (3) > (2)*; (3) > (4)**; (3) > (5)**		

4. Discussion

Researchers of game-based learning (Sung & Hwang, 2013; Shih, et al., 2010) have identified the positive impacts of playing games collaboratively on promoting the acquisition of science concepts. Thus, to enhance students' engagement in a game with a self-explanation design, this research attempted to seek the solution of collaboration and investigated its effects. The results revealed that while playing a game embedded with self-explanation, those in the collaborative mode did not outperform those who played in single-player mode (with or without self-explanation embedded). That is, adding collaboration into an educational game with self-explanation design does not necessarily result in better learning gains. This finding is resonant with van der Meij, Albers, and Leemkuil's research (2011) which suggested that collaboration in a strategy game, allowing students to practice the law of supply and demand by manipulating variables such as recruiting and stock, may not positively influence the students' learning outcomes. Similarly, researchers (Meluso, Zheng, Spires, & Lester, 2012) have also found no difference in learning performance between the collaborative and single player conditions on playing a game for science learning.

However, in this study we have found that the absence of an effect of collaboration could be attributed to a lack of engagement while answering the self-explanation prompts. After including this influential factor in the analysis, we found that the impacts of collaboration on the students' learning output became significant. That is, those who engaged themselves in answering the prompts as well as in helping their peers with the prompts tended to outperform those who were disengaged or who were in the control condition. Similarly, for those who played a solitary mode of the game with self-explanation, the highly-engaged performed better than the low-engaged and those in the control group. These findings suggest that having students collaboratively or solitarily play science-based games embedded with a self-explanation design is not sufficient to help them learn science concepts. The effects became significant and were retained longer only when the players were engaged in answering the prompts. In sum, the integration of self-explanation and collaboration strategies into game play can potentially support students' construction of science concepts. Future studies should pay more attention to promoting players' engagement in the self-explanation mechanics.

References

- Chi, M. T. H., De Leeuw, N., Chiu, M. H., & LaVancher, C. (1994). Eliciting self-explanations improves understanding. *Cognitive Science*, 18, 439-477.
- Clark, D. B. & Martinez-Garza, M. (2012). Prediction and explanation as design mechanics in conceptually integrated digital games to help players articulate the tacit understandings they build through game play. In C. Steinkuehler, K. Squire & S. Barab (Eds.), *Games, Learning, and Society: Learning and Meaning in the Digital Age* (pp. 279-305). Cambridge: Cambridge University Press
- Hsu, C.-Y., Tsai, C.-C., & Liang, J.-C. (2011). Facilitating preschoolers' scientific knowledge construction via computer games regarding light and shadow: The effect of the prediction-observation-explanation (POE) strategy. *Journal of Science Education and Technology*, 20, 482-493. doi: 10.1007/s10956-011-9298-z
- Hsu, C.-Y., Tsai, C.-C., & Wang, H.-Y. (2012). Facilitating Third Graders' Acquisition of Scientific Concepts through Digital Game-Based Learning: The Effects of Self-Explanation Principles. *The Asia-Pacific Education Researcher*, 21, 71-82.
- Johnson, C. I., & Mayer, R. E. (2010). Applying the self-explanation principle to multimedia learning in a computer-based game-like environment. *Computers in Human Behavior*, 26, 1246-1252.
- Meluso, A., Zheng, M., Spires, H., & Lester, J. (2012). Enhancing 5th graders' science content knowledge and self-efficacy through game-based learning. *Computers & Education*, 59, 497-504. doi: 10.1016/j.compedu.2011.12.019
- Nelson, B. (2007). Exploring the Use of Individualized, Reflective Guidance In an Educational Multi-User Virtual Environment. *Journal of Science Education and Technology*, 16, 83-97. doi: 10.1007/s10956-006-9039-x
- Nelson, B. (2007). Exploring the Use of Individualized, Reflective Guidance In an Educational Multi-User Virtual Environment. *Journal of Science Education and Technology*, 16, 83-97. doi: 10.1007/s10956-006-9039-x
- Roy, M., & Chi, M. T. H. (2005). The self-explanation principle in multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 271-286). New York: Cambridge University Press.
- Shih, J.-L., Shih, B.-J., Shih, C.-C., Su, H.-Y., & Chuang, C.-W. (2010). The influence of collaboration styles to children's cognitive performance in digital problem-solving game "William Adventure": A comparative case study. *Computers & Education*, 55(3), 982-993. doi: 10.1016/j.compedu.2010.04.009
- Sung, H.-Y., & Hwang, G.-J. (2013). A collaborative game-based learning approach to improving students' learning performance in science courses. *Computers & Education*, 63, 43-51. doi: 10.1016/j.compedu.2012.11.019
- van der Meij, H., Albers, E., & Leemkuil, H. (2011). Learning from games: Does collaboration help? *British Journal of Educational Technology*, 42, 655-664. doi: 10.1111/j.1467-8535.2010.01067.x
- Zea, N., Sánchez, J., Gutiérrez, F., Cabrera, M., & Paderewski, P. (2009). Design of educational multiplayer videogames: A vision from collaborative learning. *Advances in Engineering Software*, 40, 1251-1260. doi: 10.1016/j.advengsoft.2009.01.023

The Development and Evaluation of a 3D Simulation Game for Chemistry Learning: Exploration of Learners' Flow, Acceptance, and Sense of Directions

Huei-Tse HOU^{a*}, Shu-Ming WANG^b & De-Shin TSAI^a

^a*Graduate Institute of Applied Science and Technology, National Taiwan University of Science and Technology, Taiwan*

^b*Department of Information Management, Chinese Culture University, Taiwan*

^{*}hthou@mail.ntust.edu.tw

Abstract: Among various educational technology, computer game could be one of the most popular applications in recent years. Nowadays, computer games can provide a 3-dimensional (3D) immersive virtual world to increase learners' perception of presence and simulate the real world objects to support learning. The immersive learning environment, visualization of abstract concepts, and high level of interaction could benefit learners' engagement and learning outcomes. Despite previous studies have investigated the influential factors of educational gaming experience, however, in the 3D virtual world, learners might need other ability, such as sense of directions (SOD), for them to be acquainted with the virtual environment and thus can learn better. This preliminary study developed a 3D educational game to support chemistry learning. In the game, learners were to explore the virtual world to collect components for they can assemble a charcoal battery to achieve the game goal. A case study of 20 participants was conducted to assess the effectiveness of the game. Results suggested that participants gained better knowledge after playing the game. Meanwhile, participants with better SOD can more clearly capture the game goals and feel in control in the game, suggesting they were immersing in the game. Moreover, they also evaluate the game as useful to support their learning. A test of gender difference found that male and female evaluated the game in different way. Implications for the results of this study are to be used as guidance for subsequent game development and design of instructional strategies.

Keywords: Sense of Directions, TAM, Flow, educational game

1. Introduction

With the proliferation of technology, incorporating technology to support learning has been a common practice in education. Among modern technologies, computer game could be the one of the technologies that youth students are most familiar with. In this regard, previous research has focused on how to utilize the characteristics of computer games to support learning (e.g. de Freitas et al., 2012; Scoresby & Shelton, 2011; Wu, Chiou, Kao, Alex Hu, & Huang, 2012).

Previous studies suggested that educational games with adequate design and instructional support are able to promote students' engaging in learning and thus better learning outcomes (Chang, Wu, Weng, & Sung, 2012; Huang, 2011; Kiili, 2005; Wouters & van Oostendorp, 2013). However, Kiili(2006) pointed out that most of the educational games were primarily support factual information learning. The interaction between the game and the learner is similar to learning with exercise books by answering the questions it provided. Kiili(2005) stressed the experiential aspects of gaming, such as immediate feedback, goals, and challenges, that could facilitate learner's engaging in learning.

Moreover, computer games with first person perspective could increase learners' perception of presence in the virtual world, which is regarded as an important component in an immersive learning environment (Scoresby & Shelton, 2011). With the advancement of graphical computing power, nowadays, 3-dimensional (3D) computer games can present a virtual environment that allows players to interact with the objects of the game in first person perspective. 3D computer games were considered as an effective educational tool and preferred by students among various types of computer game (Amory, Naicker, Vincent, & Adams, 1999). In 3D computer games, players need to navigate the environment to achieve the goals of the game, such as arriving at specific spot or collecting objects scattered in different spaces. In this manner, players might need better sense of directions to complete the goals and challenges in the game. Otherwise, players might feel lost in the game world and demotivated to play the game. Despite few previous studies have investigated the effectiveness of using 3D educational games to support learning, with the best knowledge of the authors, none of them has researched the effects of players' sense of directions to the learning experience.

The interactivity and immersion of computer games can also be used as simulation for learning activities that involve abstract concepts or complicate procedures. For example, Liu, Cheng, and Huang (2011) employed simulation games to support computer programming learning and found that students using simulation game has better intrinsic motivation and learning experience, which thus enhanced their problem-solving skills. Pasin and Giroux (2011) used simulation game to support operation management learning, which seeks to develop decision making ability in complex situation. Their results showed that students developed more advanced decision making ability with the support of simulation game. Thus, simulation game might be an ideal tool for particular subjects, such as chemistry in this study. Learning chemistry involves abstract concepts and laboratory activities that can be dangerous and complex. Computer simulation game can be helpful in visualizing the abstract concepts and improve students' comprehension of the procedures and interest of laboratory activities before doing actual experiment (Rutten, van Joolingen, & van der Veen, 2012).

Despite previous studies have addressed the important factors of level of players' engagement with game, such as flow experience (i.e. Chang et al., 2012) or technology beliefs (i.e. Hsu & Lu, 2004), relatively little has been discussed in the context of educational game. Moreover, most of educational games were plain digital exercise book-like 2D game. As mentioned above, Amory et al. (1999) pointed out that 3D adventure games are preferred by students with its immersive environment and sense of presence in the game scene. However, when exploring the 3D virtual scene, better sense of directions (SOD) could be helpful for players to successfully locate themselves and game objects to achieve the game goal. Otherwise, players might be disoriented in the virtual world and thus feel bored with playing the game. In other words, SOD could be an influential factor that affecting players' engagement with and learning outcomes of 3D adventure-like educational games. However, to the authors' best knowledge, there is no research investigated the effects of SOD to the game experience and learning outcome. On the other hand, in traditional chemistry class, the procedures were lectured and allowed students to practice in a laboratory activity. However, the laboratory activities can be dangerous and incur extra cost if students are not familiar with the procedures. Computer simulation helps reducing the potential risk and improving students' motivation to and interest in engaging the laboratory activities (de Jong, 1991; Rutten et al., 2012). Moreover, combining the element of gaming and computer simulation could be an ideal solution to help students learn better and promote the level of engagement in learning. To address the aforementioned literature gap and utilizing the benefits of computer simulation game, this study developed a 3D adventure game to support the chemistry learning. The subject to learn is the procedure of assembling a charcoal battery. Introduction of the game is presented in the Research Method section.

Regarding gaming experience, flow could be the most mentioned experience when playing game. Flow experience refers to the perception of being total absorbed to the activity that people engaged (Scoresby & Shelton, 2011). When flow experience occurred, people may feel enjoyment, distorted sense of time, intensive control of the activity, and intrinsically motivated (Csikszentmihalyi, 1994). However, an important precondition of flow experience is the match of challenges of the activity and the actor's skill. When the challenge is greater than the actor's skill level, the actor could feel anxious. On the contrary, when the level of actor's skill level is higher than challenge, people might feel bored. Both situations prevent the actor to enter flow state (Csikszentmihalyi, 1994; Kiili, 2005). The flow experience of flow can be used as sign to assess players' engagement with the game. Moreover,

besides the flow experience, to assess players' evaluation of the game, this study also adapted two constructs of the Technology Acceptance Model (TAM, Davis, 1989). Concluding from above, the purposes of this study are as listed as following:

1. To examine the difference of learning outcomes before and after playing the game in this study.
2. To explore the plausible differences of game evaluation and gaming experience for players with different level of SOD.
3. To explore the plausible differences of game evaluation and gaming experience for players of different gender.

Results of this preliminary study can be helpful in better understanding the role of the SOD in a 3D adventure game and to players' evaluation of the game to support chemistry learning. The introduction of game and the experiment design are to be detailed in the following section.

2. Research method

2.1 Participants and procedure

This educational game used in this study is in a Doom-like 3D adventure game. The goal of the game is to find the exit of a 3D virtual maze with monsters wandering around. The maze was divided to few connected areas and there are electronic gates between these areas. Players have to collect components of charcoal battery and assemble them into charcoal battery to produce the energy to open the electronic gates. Besides, the assembled charcoal battery also provides energy for the laser gun for players to defeat the monsters in the game. Players need to follow the correct sequence of procedure to assemble the charcoal battery. Players need to assemble the charcoal battery in correct sequence once they collected all the components. While playing the game, messages and indications were provided in order to support learners to advance further steps or notice important objects. Snapshots of the game scene are as shown in Figure 1 and Figure 2.

The participants of the study are 20 students of a university in northern Taiwan. Half of them are female (female=10; male=10). The average age of participants was 24.45. The experiment was conduct in a course – Introduction to Computer that the participants enrolled. The experiment was of three sessions. In the first session, one of the authors explained the procedure to assemble a charcoal battery to the participants. An interactive animation was used to illustrate the procedure. The second session is primarily to prepare students for the needed knowledge to play the game. The goal of game and how to control the game using mouse and keyboard were clearly presented in this session. Before students can play the game, a pretest was conduct to assess students' knowledge about assembling the charcoal battery as well as the sense of direction. In the third session, students were given 25 minutes to freely explore the game. Students were asked to play the game without discussing with their peers during this session. After the game session finished, a posttest, sense of directions, technology acceptance beliefs, and flow experience were assessed.



Figure 1: A snap shot of game scene.



Figure 2: A snapshot of charcoal battery assembling game screen

2.2 Instruments

The instruments employed in this study were primarily adapted from previous validated scales. The wording has been slightly modified to fit the research context of this study. In specific, fifteen items of sense of directions were adapted from Hegarty, Richardson, Montello, Lovelace, and Subbiah (2002). Technology acceptance beliefs, i.e. perceived ease of use (PEU) and perceived usefulness (PU) were measured using the scales adapted from the Technology Acceptance Model (TAM) proposed by Davis (1989). Flow antecedents and flow experience were adapted from (Kiili, 2006). Killi (2006) proposed four constructs as flow antecedents to assess players' evaluation of the game, namely the challenge, goal, feedback, control, and playability. The flow experience was represented by players' perception of concentration, time distortion, autotelic experience, and loss of self-consciousness. There

are 22 items in total to assess the flow antecedents and experience. All the above mentioned scales were assessed using five-point Likert-scale from 1 (strongly disagree) to 5 (strongly agree). Besides, this study developed a test to assess students' procedural knowledge of assembling the charcoal battery in the pretest and posttest session. In specific, participants were asked to describe the procedure of assembling a charcoal battery with given materials. One point would be given to a correct description for each step. There are five steps in total. Up to five points would be given to a test.

3. Data Analysis and Results

3.1 Learning outcomes

SPSS 20.0 were used to analyze the collected data. The Cronbach's α reliability of scales used in this study were 0.67 (TAM scale) and 0.95 (Flow scale), suggesting modest to high reliability. For the technology acceptance beliefs, the participants generally think that the game was useful to support their learning ($M_{PU} = 3.61$) while they might not evaluate the game as easy to play ($M_{PEU} = 3.01$). For the flow antecedents, the participants evaluated the game as of challenge ($M = 3.50$), with clear goal ($M = 3.72$), providing feedback ($M = 3.67$), controllable ($M = 3.40$), and playable ($M = 3.47$). On the other hand, the participants generally reported positive flow experience as the means of the four constructs were all exceed 3.00.

A t-test of pretest and posttest was conducted to address the learning outcomes after play the game. Result suggested that the participants develop better knowledge about the assembling the charcoal battery ($t=2.728$, $p < 0.05$). Further correlation analyses were conducted to reveal the correlation among constructs. Results suggested that perceived ease of use were correlated with playability ($r = .497$, $p < 0.05$) and autotelic experience ($r = .579$, $p < 0.01$).

3.2 Individual differences

In educational research, individual differences have been regarded as an influential factor (Yukselturk & Bulut, 2009). Game-related research also suggested female and male exhibit different evaluation of game and behavioral patterns (DeLeeuw & Mayer, 2011; Yee, 2006). Moreover, this study adapted sense of directions as individual difference since the primary feature of the game is to explore the virtual maze that requires players to explore the surrounding space. Therefore, this study conducted further analyses to address the plausible individual differences among research constructs.

The results indicated that male, in contrast to female, showed higher evaluation of game feedback ($t = 2.12$, $p < 0.05$), control ($t = 2.44$, $p < 0.05$), and playability ($t = 2.03$, $p < 0.05$). Gender differences were not found in other research constructs. Regarding the plausible effects of SOD, our results showed that group with better sense of directions (higher 50% of the SOD scores, $n=11$) evaluate the game with clear goal ($t=2.25$, $p < 0.05$) and more controllable ($t = 2.23$, $p < 0.05$). Moreover, the group of better SOD also reported higher evaluation of the usefulness of the game ($t = 2.73$, $p < 0.05$). The difference of learning outcomes was not found between the students with different level of SOD. The interpretation and discussion of these results are to be presented in the following section.

4. Conclusion and subsequent research

Computer games could be one of the most popular technologies that have been used extensively day to day, especially for youth and young adults. To arouse learner's motivation to learning, increasing attention has been paid to the application of computer games in educational context. Moreover, with the advancement of graphical computing power, nowadays, computer games are able to simulate the real world objects and immersing environment for players to explore. This study developed an educational 3D adventure game to simulate the procedure of assembling a charcoal battery and conducted a

preliminary experiment to assess the effectiveness of the game to support learning and collect learners' reactions for further game development.

First of all, the result suggested that the educational game helped participants better understand the procedure of assembling the charcoal battery. In the posttest, participants generally gained higher score, which indicated they are more familiar with the procedure of assembling a charcoal battery. This result provided a preliminary support for the effectiveness of the game in this study. Previous study suggested that students tend to participate in the simulation game in a superficial manner. However, simulation game was considered an ideal training tool to intrigue learners' engagement and intrinsic motivation with adequate instructional supports (Liu et al., 2011). Moreover, in science education, computer simulation can be used to improve students' to be familiar with the procedure of laboratory activities before the actual lab activity sessions (Rutten et al., 2012). The computer simulation can be helpful for students to be familiarized with the abstract concepts and complicate procedure, which reflected in improved learning outcomes. By incorporating the game elements, as the 3D adventure in this study, the level of learners' interest in learning and engagement in the learning process are expected to be increased (Chang et al., 2012; Hwang, Wu, & Chen, 2012; Liu et al., 2011).

As typical gamers are more likely to be male (Griffiths, Davies, & Chappell, 2004) and individual differences are an important factor in educational research, this study further conducted a mean difference test of the research constructs for gender. Results indicated there were gender differences in three flow antecedents, namely the feedback, control and playability. This result might due to the different presences of the game content between male and female. Scoresby and Shelton (2011) found that female might not like the killing content in the first person perspective game, such as shooting monsters. In turn, female might possess lower perception of presence in the game and thus results in lower engagement in learning and learning performance. The game in this study is a Doom-like 3D adventure game. While players wandering around the 3D maze, they will encounter randomly appeared monsters and have to fight with them to reach the gates and complete the game goal. The incorporation of monsters is to increase the extent of challenge and excitement in game, which were considered important antecedents of flow experience. However, female might not like such game content. As a result, they might value the game less playable and controllable and neglect the feedback in the game. Therefore, gender differences in the game type and content should be considered while design an educational game in order to improve the engagement of learners.

Moreover, the game in this study is a 3D adventure game. To achieve the game goal, players have to collected the charcoal battery components scattered in the virtual 3D maze. Results of this study showed that students with better SOD score not only more likely to think of the game as useful to support learning, but also better understand the goal of the game and evaluate the as more controllable than those who have lower SOD score. Better SOD helps players to capture the way to explore the 3D virtual world. By knowing where they are and where to go, they can more easily to collect the needed components and use the assembled charcoal battery to go through the correct gates to achieve the game goal. On the contrary, without SOD, players might feel bored with the game as they can be lost in the maze and fail to advance to the new spaces. Nonetheless, this study didn't find the difference of learning outcomes between students of higher level SOD and lower level SOD. The small sample size and short game session (25 minutes) might pose limitation on the diversity of the learning outcomes. This study would subsequently conduct a larger scale of experiment to address this issue.

Despite results of this study showed significant improvement of the learning outcomes, however, in the preliminary version of the game, the proper scaffolding of the subject-domain knowledge was not incorporated. Without adequate feedbacks, students might mostly adopt trial-and-error strategy to achieve the game goal even though they have engaged in playing the game. With proper guidance and scaffolding, students might be able to reflect on the subject that the game is to help them to learn instead of just engaging in playing the game. Previous study also suggested that besides the game content, the success of incorporating game to support learning require adequate instructional support (Wouters & van Oostendorp, 2013).

Lastly, results of this study suggested that SOD is an influential factor in affecting players' evaluation of the game and their extent of engagement with the 3D adventure game. Despite the first person perspective and the immersive virtual environment can be helpful to increase the perception of presence, players with better SOD are more likely to grasp the game goals and control the process of gaming. The in-depth engagement with the game could help them learn better. However, these findings

also brought up another consideration in developing the 3D adventure game for support learners without good SOD for learning. How to design the game content and control as well as instruction strategy to address this individual difference worth further exploration.

5. Research Limitations

The primary purpose of this study is to assessing learners' experience and learning outcomes with a 3D simulation game for chemistry learning. In the experiment of this study, students were allowed to freely play the coal battery for 25 minutes. However, the length time might not be sufficient for students to experience flow. Students might need more time to learn how to operate the game and hone their skills to meet the challenges in the game as a prerequisite condition of flow experience (Csikszentmihalyi, 1994). In our subsequent research, students will be allowed to play the 3D simulation game in a longer session. Meanwhile, they skills to control the game will also be examined to address the effect of individual difference to flow experience. Moreover, the small sample size might pose limitation to the interpretation of current results of this study. In the future study, more samples are to be collected to improve the reliability of research results. More individual differences, such as game experiences, game preferences, are to be incorporated as control variables. Lastly, the results of current research are to be employed to improve the future version of the game and the design of the instruction strategy to help students learn better.

Acknowledgements

This research was supported by the projects from the National Science Council, Republic of China, under contract number NSC-102-2511-S-011-001-MY3, NSC-100-2628-S-011-001-MY4, and NSC-101-3113-S-011-001.

Reference

- Amory, A., Naicker, K., Vincent, J., & Adams, C. (1999). The Use of Computer Games as An Educational Tool: Identification of Appropriate Game Types and Game Elements. *British Journal of Educational Technology*, 30(4), 311-321.
- Chang, K.-E., Wu, L.-J., Weng, S.-E., & Sung, Y.-T. (2012). Embedding Game-Based Problem-Solving Phase Into Problem-Posing System For Mathematics Learning. *Computers & Education*, 58(2), 775-786.
- Csikszentmihalyi, M. (1994). *Flow: The Psychology of Optimal Experience*. New York, NY: Simon & Schuster.
- Davis, F. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, 13(3), 319-340.
- de Freitas, S., Earp, J., Ott, M., Kiili, K., Ney, M., Popescu, M., Stanescu, I. (2012). Hot Issues in Game Enhanced Learning: The GEL Viewpoint. *Procedia Computer Science*, 15(0), 25-31.
- de Jong, T. (1991). Learning and instruction with computer simulations. *Education and Computing*, 6(3-4), 217-229.
- DeLeeuw, K. E., & Mayer, R. E. (2011). Cognitive Consequences of Making Computer-Based Learning Activities More Game-Like. *Computers in Human Behavior*, 27(5), 2011-2016.
- Griffiths, M. D., Davies, M., & Chappell, D. (2004). Online Computer Gaming: A Comparison of Adolescent And Adult Gamers. *Journal of Adolescence*, 27(1), 87-96.
- Hegarty, M., Richardson, A. E., Montello, D. R., Lovelace, K., & Subbiah, I. (2002). Development of A Self-Report Measure of Environmental Spatial Ability. *Intelligence*, 30(5), 425-447.
- Hsu, C.-L., & Lu, H.-P.. (2004). Why Do People Play On-Line Games? An Extended TAM with Social Influences and Flow Experience. *Information & Management*, 41(7), 853-868.
- Huang, W.-H. (2011). Evaluating Learners' Motivational and Cognitive Processing in An Online Game-Based Learning Environment. *Computers in Human Behavior*, 27(2), 694-704.
- Hwang, G.-J., Wu, P.-H., & Chen, C.-C. (2012). An Online Game Approach For Improving Students' Learning Performance in Web-Based Problem-Solving Activities. *Computers & Education*, 59(4), 1246-1256.

- Kiili, K. (2005). Digital Game-Based Learning: Towards An Experiential Gaming Model. *The Internet and Higher Education*, 8(1), 13-24.
- Kiili, K. (2006). Evaluations of An Experiential Gaming Model. *Human Technology*, 2(2), 187-201.
- Liu, C.-C., , Cheng, Y.-B., & Huang, C.-W.. (2011). The Effect Of Simulation Games on The Learning of Computational Problem Solving. *Computers & Education*, 57(3), 1907-1918.
- Pasin, F., & Giroux, H. (2011). The Impact of A Simulation Game on Operations Management Education. *Computers & Education*, 57(1), 1240-1254.
- Rutten, N., van Joolingen, W. R., & van der Veen, J. T. (2012). The Learning Effects of Computer Simulations in Science Education. *Computers & Education*, 58(1), 136-153.
- Scoresby, J., & Shelton, B. (2011). Visual Perspectives within Educational Computer Games: Effects on Presence And Flow within Virtual Immersive Learning Environments. *Instructional Science*, 39(3), 227-254.
- Wouters, P., & van Oostendorp, H. (2013). A Meta-Analytic Review of The Role of Instructional Support In Game-Based Learning. *Computers & Education*, 60(1), 412-425.
- Wu, W.-H., Chiou, W.-B., Kao, H.-Y., Hu, C.-H., & Huang, S.-H. (2012). Re-Exploring Game-Assisted Learning Research: The Perspective of Learning Theoretical Bases. *Computers & Education*, 59(4), 1153-1161.
- Yee, N. (2006). Motivations for Play in Online Games. *CyberPsychology & Behavior*, 9(6), 772-775.
- Yukselturk, E., & Bulut, S. (2009). Gender Differences in Self-Regulated Online Learning Environment. *Journal of Educational Technology & Society*, 12(3), 12-22.

Pre-service teachers' learning and frustrations during the development of serious educational games (SEGs) for learning biology

Mei-En HSU, Meng-Tzu CHENG *

National Changua University, Changua

*mtcheng@cc.ncue.edu.tw

Abstract: The purpose of this study is to explore pre-service teachers' learning and frustrations during the development of serious educational games (SEGs) for learning biology. A two-credit, 18-week-long course, entitled *Computers in Teaching and Learning Biology* was offered in fall semester of 2012. A total of 12 pre-service teachers registered in this course –and in-depth interviews with every pre-service teacher were conducted after the conclusion of semester. According to their responses, we found that most of them expressed positive attitudes towards this course but still had some difficulties and challenges in taking this course. Pre-service teachers generally reflected that the instructional time of the course was too short causing that they still didn't really know how to program and code using ActionScript3.0. Discussions regarding the obtained results and suggestions for future work are further provided.

Keywords: Serious educational games (SEGs), pre-service teachers, biology learning, teaching with technology

1. Introduction

It goes without doubt that we are living in a digital era where technology is shaping the way we live, think, and learn. Websites are becoming more important information resources than books and magazines, and we have now online access to tens of thousands learning materials and activities. Moreover, debates about the educational potential of playing video games are decreasing and more than half of the parents now believe that video game play provides mental simulations and is a positive part of child's life (Entertainment Software Association, 2013). As a result, various methods have been created to harness the power of technology to support our education. The use of video games in training and learning environments, known as serious games (SGs) or science educational games (SEGs) (Annetta, 2008), is one of the increasingly relevant trends which transforms our education because new digital innovations has significantly changed our pedagogical perspectives. Supporters of SEGs claim that video games have a huge potential to play as a vehicle for learning and research evidence shows that its positive impact on students motivation, engagement, and learning outcomes seems promising (Cheng & Annetta, 2012; Clark et al., 2011; Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012; Echeverría et al., 2011; Gee, 2003a, 2003b; Giannakos, 2013; Lim, 2008; Paraskeva, Mysirlaki, & Papagianni, 2010; Prensky, 2001; Sánchez & Olivares, 2011).

The use of SEGs is particularly important to science education, as many scientific concepts which are invisible in the real world are generally abstract and difficult to grasp can be portrayed in the virtual world. In addition, scientific inquiry ability and problem-solving skills often require long-term cultivation and repeated practices. The complex structure of science, the trouble of reasoning about abstract concepts, and the challenges that arise in problem solving and scientific inquiry render students a sense of anxiety and difficulties in learning science compared to other subjects (Halff, 2005). However, SEGs which combine game characteristics with science content not only motivate and absorb students in the embedded science learning activities, but also increase the probability of bridging virtual reality into reality in numerous dimensions, providing students with authentic learning wherein they are allowed to repeatedly experience things that are impossible in the real world without worries of real life consequences (Cheng, Annetta, Folta, & Holmes, 2011).

After making a comprehensive survey of literature, we see that most of the available evidence always focuses on students' science learning through SEG play; however, research that emphasizes pre- and in-service teachers' perceptions and implementations of using SEG or their professional development through designing an SEG is comparatively lacking. General people, especially teachers,

always consider creating a game-based learning environment to be expensive and arduous. Moreover, although many governments worldwide have invested money in developing SEGs that facilitate science learning in elementary and secondary settings (eg. <http://www.fas.org/programs/ltp/games/>), accessible resources of SEGs in Taiwan or projects which are funded by Taiwan's government endeavoring to create and develop SEGs are relatively deficient. All of these make it become more challenging and difficult for Taiwanese teachers to integrate SEGs into science classrooms.

Therefore, in fall semester of 2012, a two-credit, 18-week-long course, entitled *Computers in Teaching and Learning Biology*, was delivered to 12 students who are enrolled in teacher education program (pre-service teachers), with an aim to provide these pre-service teachers with an experience of project-based learning (in this case, project refers to the development of an SEG). In this course, students learned Adobe Flash and programming of ActionScript 3.0 and were asked to develop SEGs for biology learning by themselves. They were required to present their SEG idea and script (SEG prototype) in the midterm and demonstrate their SEG in the final. In-depth interviews with every pre-service teacher were conducted and recorded after the conclusion of the semester to collect data regarding feedback and comments towards this course, as well as the challenges and difficulties encountered.

2. Research Design

The course Computers in Teaching and Learning Biology

The course was a two-credit, 18-week-long course. There were a total of 12 students registered in this course. They were finally divided into 4 groups (2-4 individuals/group) to carry the project out by group collaboration. In this course, students were taught basic principles of ActionScript 3.0 programming so that they can use Adobe Flash Player as a platform to demonstrate their created SEGs.

The course schedule can be divided by midterm into two parts. Before midterm (week 1-8), the instructor placed much more emphasis on basic concepts and fundamentals of ActionScript 3.0. After midterm (week 10-16), the instructor in turn introduced specific programming which each group needs according to their SEG script. Two presentations and one paper-and-pencil test were required. Each group had to present game idea and script (SEG prototype) in the midterm (week 9) and demonstrate the SEG (end-product) they created in the end of the semester (week 18). Moreover, there was an exam assessing what they had learned about ActionScript 3.0 in the final (week 17). In addition to in-class practices, five homework assignments were also distributed to ensure that students did learn the programming which was taught. Although the 18-week lectures mainly emphasized the development of programming skills, each group had to regularly discuss their SEG idea and script with a science education expert at times out of classes to ensure the validity of scientific content and pedagogical methods embedded in their games.

Data collection

To explore the pre-service teachers' experiences and reflections on designing SEGs for learning biology, several tape-recorded in-depth interviews with every pre-service teacher were conducted after the semester. The pre-service teachers were asked to answer several leading questions. Each interview with each interviewee lasted about 15-20 minutes. With interviewee permissions, all the interviews were transcribed verbatim into transcriptions for data analysis. These transcriptions were first separated into narrative segments that expressed a specific idea/concept or described a particular experience, and then these narrative segments were again read repeatedly by researchers to find emerging categories. Recurring and qualitative distinct themes, conclusions, and explanations were drawn from these categories.

3. Result

What did the pre-service teachers learn from this course?

Pre-service teachers according to Table 1, pre-service teachers' feedback regarding what they had learned from the course is exactly in alignment with the learning outcomes expected by the instructor. It is surprising to the authors that most of the pre-service teachers may have placed their focus on learning to program with Flash or making games, rather than designing and making "serious educational" games. It may be due to that the fact that the pre-service teachers in this study lacked relevant

knowledge or ability in programming with Flash, hence their insufficient prior knowledge in programming may have distracted their attention during their learning processes. Consequently, they paid most of their attention to programming rather than integrating educational purposes into the games they designed and made.

Table 1: The pre-service teachers' self-reported learning outcomes derived from taking the course (n=12)

Learning outcome	n
1. How to program with Flash	6
2. Designing and making games	4
3. How to design an serious educational game	2
4. Transferring the domain knowledge into a serious educational game	1
5. How to collaboratively work with others	1

The distinctions between the pre-service teachers' expectations and the actual practices of this course?

Table 2 summarizes the distinctions that the pre-service teachers mentioned. Only two of the twelve pre-service teachers expressed that the actual practices of the course were almost the same as what they expected before taking the course. However, the other teachers mentioned various distinctions between what they expected and the actual practices of the course. Most of the pre-service teachers thought that "More efforts should be paid during taking this course." Also some pre-service teachers said that "Making a game is not so easy."

It seems that the workload of this course was too heavy for the pre-service teachers. In particular, for the pre-service teachers without prior knowledge in programming with Flash, as it took them substantially longer periods of time to complete their game design.

Table 2: The distinctions between the pre-service teachers' expectations and the actual practices of this course (n=12)

distinction	n
1. More efforts should be paid during taking this course	5
2. Making a game is not so easy	4
3. Programming with Flash is difficult	3
4. The need for collaboration in making a serious educational game	1

Pre-service teachers' perceptions of their learning processes

As revealed in Table 3, half of the pre-service teachers perceived their learning processes as "interesting and meaningful" or "experiencing student-centered instruction". However, it should also be noticed that other pre-service teachers expressed less positive perceptions regarding this course. In sum, although the loading of the course was heavy, half of the pre-service teachers still had positive perceptions on taking this course. However, others expressed less positive perceptions on their learning processes, suggesting the need for modifying the design and arrangement of this course in the future.

Table 3: Pre-service teachers' perceptions of their learning processes (n=12)

Perception	n
1. Experiencing interesting and meaningful learning	5
2. I spent a lots of time in coding	2
3. Experiencing student-centered instruction	1
4. The loading increased; however, there was insufficient time	1
5. More detailed explanations from the instructor will be helpful	1
6. I could not follow the teacher's instruction	1
7. Lots of homework to be done after school	1

Pre-service teachers' frustrations during taking this course

As shown in Table 4, most of the teachers mentioned that they felt frustrated in programming and coding. Compared with aforementioned frustrations, some teachers expressed their frustrations were caused by further personal commitments. It seems that the more efforts were made by these pre-service

teachers in this course, the more frustrated they might be oriented to feel. These frustrations might be resulted from the pre-service teachers' insufficient experiences of mastering in designing and making SEGs.

Table 4: Pre-service teachers' frustrations during taking this course (n=12)

Frustration	n
1. Programming and coding	8
2. Completing the homework	1
3. How to integrate what I have learnt into the game	1
4. How to implement our design	1
5. Low quality of the game	1

Pre-service teachers' suggestions on instruction

The pre-service teachers in this study provided three major suggestions for the instructor:

- More basic instruction in programming and coding will be helpful.
- More instructional time will be needed.
- Classroom videos and more detailed handouts for students will be helpful.

Pre-service teachers' recommendations on the arrangement of the course

The pre-service teachers in this study also provided three major recommendations on the arrangement of the course:

- The instructional time of the course should be extended.
- The loading of homework should be reduced.
- The participants of the course should be limited.

4. Discussion

Time issue

The insufficiency of instructional time seems the major defect of this course as mentioned. In fact, the curriculum of teacher preparation programs in Taiwan has a rather tight schedule, so that teacher preparation courses related to effective teaching with technology offered by teacher education institutes are relatively few. Moreover, even the courses are offered, almost all of them are elective and two-credit only. Hence, the time issue becomes a dilemma for teacher educators in Taiwan. On the one hand, if the course is offered as a three- or four- credit course, the redundant credit(s) might be not able to be counted into the required credits for graduation. On the other hand, if the course remains two-credit, students might think the difficulty is too great for a two-credit course. Both of the aforementioned situations will significantly decrease students' motivations of taking this course, which clearly reflects the inadequate arrangement of the current teacher preparation courses for improving the technological literacy of pre-service teachers.

Programming issue

Almost all of these pre-service teachers mentioned that they felt frustrated in programming and coding. The major problem is they usually lacked sufficient practices after school and didn't effectively construct an integrated understanding. It is impossible for pre-service teachers or others to gain mastery within a short time period, particularly when the skill in question is complex programming. Substantially more time is required to allow repetitive practice in order to construct an integrated understanding of the execution of computer programs, so that mastery of programming can be gained.

Course loading issue

The criteria for assessing student performance in this course include participation (10%), homework assignments (30%), final paper-and-pencil exam (10%), midterm presentation of prototype (20%), and final demonstration (30%). Despite the midterm presentation of prototype and final demonstration of SEGs that were group work, the five homework assignments and final paper-and-pencil exam required pre-service teachers to finish individually. However, as mentioned earlier that these pre-service teachers are undergraduates who are majoring in biology and are enrolled in teacher education program, meaning that they have to take responsibilities for not only the assignments in this course, but also the

other requirements of the department of biology. Needless to say, the students with biology major would have the tightest course schedule compared to students with other majors since they need to carry out many laboratory experiments. Their feeling was that the course loading was too heavy was therefore natural. Not enough instructional time to allow these pre-service teachers to have sufficient practice in classes again becomes the major issue.

Transfer/integration issue

The transfer/integration issue is difficult, but also important. However, it is frustrating, but not surprising to us, to find that some pre-service teachers still have difficulties in transferring what they have learned into games or completing their games. According to the results, we can see that there might be two transfers/integrations that needed to be taken into account. First is the “transferring/integrating” of their professional knowledge in biology and biology teaching into the game format (integrating scientific concepts, educational objectives, and instructional strategies with game features), and the other is “transferring/integrating” the design of prototype into a real game product. These pre-service teachers showed fewer difficulties in the first transfer/integration after regularly discussing with the science education expert and their group members. However, they were not able to properly transfer the design of prototype into a real game product, even though they might be able to write a very good game script and develop a sound prototype.

5. Suggestions for future work

Offering more credits and instructional time for the course

We think that the credits and instructional time for the course should be increased. After discussing with these pre-service teachers, we figure out that the best way is to offer this course in two semesters, with two-credits for each semester. In the first semester, pre-service teachers will learn the basic programming structure of ActionScript 3.0, the basic ideas of art design, and video and audio making process, and to come up with a sound and detailed game prototype. If more credit hours are offered, their course loading would be significantly decreased.

Cooperating with other professional departments

We highly suggest that this course can be offered as an instruction cooperating with other professional departments, such as the department of computer science and information engineering or management. If there can be cooperation between different departments to offer this course, there would be students with different majors taking it. Consequently, the student groups in this course can be heterogeneous. This kind of heterogeneous grouping is an enhancer of group work because within the group, everyone learns from everyone else, and students are given more opportunities to participate in classes

Providing more scaffolds and social organizations for helping student learning in this course

The provision of more scaffolds is absolutely necessary. The use of exemplary cases is also highly encouraged. For an act or an event, there should be many different methods of programming. If the exemplary cases of programming for the same act/event can be provided, then the pre-service teachers or students can analyze and compare the differences and similarities between two or more examples. Moreover, a large number of websites that provide resources with open codes should be suggested. In so doing, it might be much more helpful for pre-service teachers and students in coming up with their own logic and method of programming. Besides, pre-service teachers mentioned that the in-class instructions should be recorded and saved as tutorial videos. These videos then can be uploaded onto the web so that students could practice and rehearse repeatedly after school.

Administering appropriate number of formative assessments for self-diagnosis and instruction adjustment

Although some participants argued the course loading was too heavy because of so many homework assignments, we still recommend appropriate number of formative assessment should be administrated during the implementation of the course. However, the way it is administrated could be slightly modified. For example, it could be conducted as a format of self-assessment on-line that students decide when and how many times they would like to carry out these assessments. Or the assessments and assignments can be worked on through teamwork instead of being finished individually.

6. Conclusions

The current study explored a group of pre-service teachers' experiences and reflections on a course focusing on learning by designing SEGs. Most of the pre-service teachers expressed positive attitudes towards this course. However, they also mentioned some difficulties and challenges in taking the course. Their experiences and reflections on taking the course provided some important implications for teacher educators and educational game designers. In particular, the suggestions derived from the experience of implementing the course, such as the provision of additional resources and scaffolds for students' learning during this course, would be crucial. Also, it is highly suggested that this course could be offered as an instruction in cooperation with other professional departments, such as the department of computer science and information engineering or management. Consequently, pre-service teachers' learning outcomes as well as the quality of the SEGs they design could be improved.

Acknowledgements

This work was funded by the National Science Council (NSC), Taiwan, under grant contract no. NSC 101-2511-S-018-004-MY3. All the supports are highly appreciated.

References

- Annetta, L. A. (2008). *Serious educational games*. The Netherlands: Sense Publishers.
- Cheng, M.-T., & Annetta, L. (2012). Students' learning outcomes and learning experiences through playing a Serious Educational Game. *Journal of Biological Education*, 46(4), 203-213. doi: 10.1080/00219266.2012.688848
- Cheng, M.-T., Annetta, L. A., Folta, E., & Holmes, S. Y. (2011). Drugs and the Brain: Learning the impact of methamphetamine abuse on the brain through virtual brain exhibit in the museum. *International Journal of Science Education*, 33(2), 299-319.
- Clark, D. B., Nelson, B. C., Chang, H.-Y., Martinez-Garza, M., Slack, K., & D'Angelo, C. M. (2011). Exploring Newtonian mechanics in a conceptually-integrated digital game: Comparison of learning and affective outcomes for students in Taiwan and the United States. *Computers & Education*, 57(3), 2178-2195. doi: 10.1016/j.compedu.2011.05.007
- Connolly, T. M., Boyle, E. A., MacArthur, E., Hainey, T., & Boyle, J. M. (2012). A systematic literature review of empirical evidence on computer games and serious games. *Computers & Education*, 59(2), 661-686. doi: 10.1016/j.compedu.2012.03.004
- Echeverría, A., García-Campo, C., Nussbaum, M., Gil, F., Villalta, M., Améstica, M., & Echeverría, S. (2011). A framework for the design and integration of collaborative classroom games. *Computers & Education*, 57(1), 1127-1136. doi: 10.1016/j.compedu.2010.12.010
- Entertainment Software Association. (2013). Essential facts about the computer and video game industry. Retrieved from http://www.theesa.com/facts/pdfs/ESA_EF_2013.pdf
- Gee, J. P. (2003a). High Score Education: Games, not school, are teaching kids to think. *Wired*, 11(5). Retrieved from <http://www.wired.com/wired/archive/11.05/view.html>
- Gee, J. P. (2003b). *What video games have to teach us about learning and literacy*. New York: Palgrave.
- Giannakos, M. N. (2013). Enjoy and learn with educational games: Examining factors affecting learning performance. *Computers & Education*, 68(0), 429-439. doi: <http://dx.doi.org/10.1016/j.compedu.2013.06.005>
- Halff, H. M. (2005). *Adventure games for science education: Generative methods in exploratory environments*. Paper presented at the 12th International Conference on Artificial Intelligence in Education, Amsterdam, the Netherlands.
- Lim, C. P. (2008). Global citizenship education, school curriculum and games: Learning Mathematics, English and Science as a global citizen. *Computers & Education*, 51(3), 1073-1093. doi: 10.1016/j.compedu.2007.10.005
- Paraskeva, F., Mysirlaki, S., & Papagianni, A. (2010). Multiplayer online games as educational tools: Facing new challenges in learning. *Computers & Education*, 54(2), 498-505. doi: 10.1016/j.compedu.2009.09.001
- Prensky, M. (2001). *Digital game-based learning*. New York: McGraw-Hill.
- Sánchez, J., & Olivares, R. (2011). Problem solving and collaboration using mobile serious games. *Computers & Education*, 57(3), 1943-1952. doi: 10.1016/j.compedu.2011.04.012

Criteria and Strategies for Applying Concept-Effect Relationship Model in Technological Personalized Learning Environment

Patcharin PANJABUREE^{a*} & Niwat SRISAWASDI^b

^a*Institute for Innovative Learning, Mahidol University, Thailand*

^b*Faculty of Education, Khon Kaen University, Thailand*

*panjaburee_p@hotmail.com

Abstract: Recent progress in computer and communication technology has encouraged the researchers to demonstrate the pivotal influences of technological personalized learning environments on student learning performance improvement. Many researchers have been investigating the development of such learning environment by basing upon the concept-effect relationship model; nevertheless, the criteria of establishing a technological personalized learning environment based on the concept-effect relationship model have not yet been clearly defined, not to mention the strategies of conducting effective conceptual learning problem diagnosis and effective learning activities. To resolve these problems, this paper presents the basic criteria and strategies of technological personalized learning based on the concept-effect relationship model, and identify the necessary check items as well for the development of such learning environment. Illustrative example of conducting technological personalized learning and the requirements of setting up learning environment are also presented at the end of this paper.

Keywords: Adaptive learning, e-learning, testing and diagnostic system, concept-effect relationships

1. Introduction

In past decade, the rapid advance of computers and communication technologies has promoted the utilization of technological applications in science, technology, and mathematics (STM) educations. The technology in STM education serves as a key ingredient to enhance learning as it helps produce creative and lifelong learning for individual students and promotes personalized learning as well. The technological personalized learning environment is referred to enable individual students to improve their own learning performance (Chen, 2008; Chen, 2011). Consequently, many researchers have developed technological personalized learning environment based on several approaches, models, and algorithms including Bayesian cybernetics, fuzzy rules, genetic algorithms, clustering techniques and concept-effect relationship model (Bai & Chen, 2008a; Cheng, Lin, Chen, & Heh, 2005; Kaburlasos, Marinagi, & Tsoukalas, 2008; Panjaburee, Hwang, Triampo, & Shih, 2010).

In the recent years, several researchers have applied concept-effect relationship model to develop technological personalized learning environment (Bai & Chen, 2008a, 2008b; Chen, 2008; Chen & Bai, 2009; Günel & Aşlıyan, 2010; Hwang, 2003; Panjaburee et al., 2010, Hwang, Panjaburee, Shih, & Triampo, 2013; Chu, Hwang, Tseng, & Hwang, 2006). Successful uses of this model not only demonstrated the benefits of applying it for coping with learning diagnosis problems but also enhanced learning performance in several areas including natural science, mathematics, and health education. However, the difficulty of applying it has been mentioned, not to mention the strategies of conducting effective conceptual learning problem diagnosis and effective learning activities. To cope with these issues, this paper attempts to propose the criteria and strategies of establishing a technological personalized learning environment based on the concept-effect relationship model; moreover, the necessary check items for the development of such learning environment are identified. In addition, several examples for conducting technological personalized

learning based on the concept-effect relationship model and the requirements of setting up learning environment are served as a useful reference for those who are in this area.

2. Characteristics of concept-effect relationship (CER)

Hwang's learning diagnosis procedure (Hwang, 2003), which will be referred to as the basic learning diagnosis procedure throughout the rest of the paper, serves as the starting point of the testing and diagnosing procedure development. The concept-effect relationship on topic 'System of Linear Equations' for ninth-grade Thai students based on a standard Mathematics curriculum in Thailand (Ministry of Education, 2002), as shown in Figure 1, was used to show characteristics of CER in this study. In Figure 1., there are 12 concepts to monitor students' comprehension of algebra course in grades 7 to 9:

C1 Pattern and Relation: the basic concepts of an unknown and development of a sequence of terms;

C2 Equation: the concept of equals sign (=) or equals or equivalence and equation;

C3 Number and Operation: generalized arithmetic laws such as basic number and operations, order of operations, commutative, distributive, and identity properties of addition and multiplication;

C4 Solution of the Equation: solving equations by substituting numerical values and simplifying, checking by successive trial and error and correction;

C5 Properties of Equalities: one of possible concepts used to solve linear equation with one variable;

C6 Constructing Linear Equation with One Variable: generating algebraic expressions;

C7 Solving Linear Equation with One Variable: substituting numerical values or properties of equalities and checking the solution;

C8 Least Common Multiple (LCM): one of the possible concepts used to solve linear equation with two variables;

C9 Ordered Pair and Graph: understanding co-ordinates and graphs in order to offer an algebraic solution;

C10 Word Problem of Linear Equation with One Variable: generating an equation from a descriptive statement, and solving problem;

C11 Solving Linear Equation with Two Variables: using the concepts co-ordinates, graphs, properties of equalities, and LCM; and

C12 System of Linear Equations: generating linear equations with two variables from a situation and solving the problem.

This CER represents the relationships among concepts, for example, the concept 'Properties of Equalities' must be learnt before 'Solving Linear Equation with One Variable'. Likewise, the concept 'Solving Linear Equation with One Variable' must be learnt before 'Word Problem of Linear Equation with One Variable' and 'Solving Linear Equation with Two Variables'. In addition, the concept 'LCM' and 'Ordered Pair and Graph' may be possible concepts that can be used to solve linear equation with two variables. When the relationships among concepts are defined, it is possible to explore the learning barriers of each student and provide personalized suggestions of remedial learning. For example, if a student fails to learn the concept 'Solving Linear Equation with One Variable' this may be because he/she did not learn the concept 'Solution of the Equation' and 'Properties of Equalities' well. In this case, we would suggest that the student should study 'Solution of the Equation' and 'Properties of Equalities' more thoroughly before attempting 'Solving Linear Equation with One Variable'.

Following the construction of CER the main problem is how to diagnose student conceptual learning problems. Obviously, previous research used the CER to diagnose student conceptual learning problems in five steps (Hwang, 2003; Hwang et al., 2008):

(1) Constructing the CER for the subject unit.

(2) Presetting the weight values between test item and related concepts.

(3) Calculating the incorrect answer rate for each student in each concept.

(4) Defining a concept which affects the learning of other related concepts.

(5) Providing feedback and corresponding learning material to each student.

These five steps of the use of CER are called the CER model in diagnosing student conceptual learning problem in technological personalized learning environment.

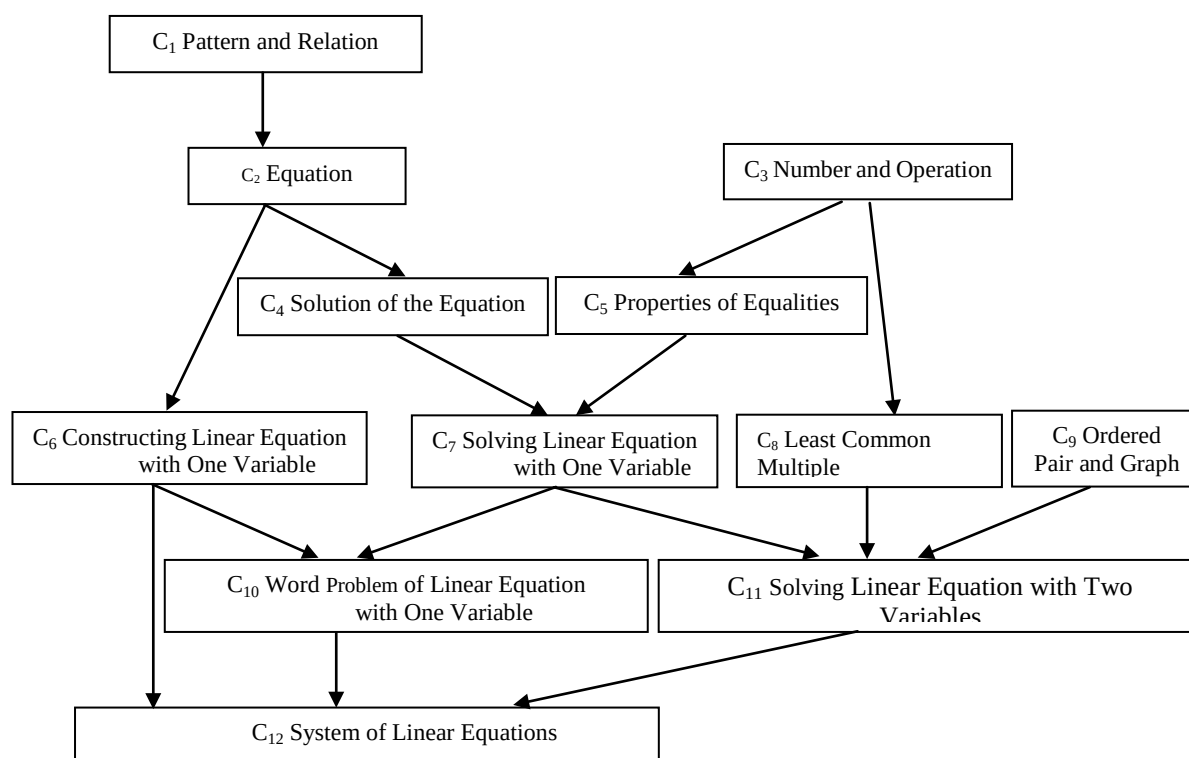


Figure 1. A concept-effect relationship (CER) for topic “System of Linear Equations” (Panjaburee, Triampo, Hwang, Chuedoung, & Triampo, 2013)

3. Criteria and strategies for applying concept-effect relationship model in technological personalized learning environment

Although CER model has attracted much attention from the researchers in developing testing and diagnostic system for technological personalized learning environment, when applying the CER model, the criteria of constructing the CER and presetting weight values between test item and related concepts have not been clearly defined. In the recent years, researchers in this area have different views of those criteria. One view is using single expert/ teacher to construct CER and define weight values between test item and related concepts, which is a very subjective or unintentionally inconsistency decision making (Hwang 2003; Hwang, Tseng, & Hwang 2008; Lee, Lee, & Leu, 2009). With this imprecise decision, different expertise or understanding of each portion of knowledge in the same domain subject unit that allows multiple experts/ teachers to making decision cooperatively can be to integrate the opinions of multiple experts/ teachers to get more high quality CER (Hwang et al., 2013) and weight values between test item and related concepts (Panjaburee et al., 2010; Wanichsan, Panjaburee, Laosinchai, Triampo, & Chookaew, 2012). It is clearly identified that the cooperation of multiple experts/ teachers makes more precise in diagnosing conceptual learning problems and truthful conceptual learning suggestions to individual students during learning in technological personalized learning environment.

Accordingly, from previous literature review, we shall provide STEM educators the potential criteria when applying the CER model in technological personalized learning environment as follows:

1. A CER is a construction of prerequisite relationships among concepts in specific subject unit before starting learning in technological personalized learning environment; that is, multiple experts/ teachers which have the same domain subject learning unit and similar teaching experience

can work together, implying that the precise CER is able to construct by the cooperation of multiple experts/ teachers.

2. Following the precise CER construction, a test sheet in multiple-choice format is needed to develop covering all concepts in the CER.

3. Weight values between test item and related concepts are need to set before diagnosing conceptual learning problem in technological personalized learning environment; that is, multiple experts/ teachers which have the same domain subject learning unit and similar teaching experience can work together, implying that the precise weight values are able to define concept which affects the learning of other related concepts correctly.

4. An application of CER model in technological personalized learning environment can actively provide personalized conceptual learning guidance to students in the right way at the right time based on the submitted answers of all test items.

To conduct the technological personalized learning environment based on the CER model, it is necessary to define the strategies in the real classroom as follows:

1. Upon showing an illustrative example of CER, guide the teachers to construct their own CER in specific subject unit. An expert system needed to be developed to automatically integrate those given by multiple teachers. If there is any conflict occurs during constructing CER, it can be conducted by using online or face-to-face discussions.

2. Guide the teachers to develop a test sheet in multiple-choice format covering all concepts in the integrated CER from multiple teachers.

3. Upon showing an illustrative example of determining weight values between test item and related concepts in the test sheet, guide teachers to presetting their own values (i.e., 1, 2, 3, 4, or 5 ranging from weak to strong relationship). Accordingly, an expert system needed to be developed for automatically integrating those given by multiple teachers. If there is any conflict occurs during integration, it can be conducted by using online or face-to-face discussions for reconsidering the conflicting values.

4. Take the online tests provided by testing and diagnostic system. The testing and diagnostic system will analyze the test results, detecting conceptual learning problems, generate learning guidance, and provide corresponding learning material to each students. The enhanced learning paths and corresponding learning material can be provided when the testing and diagnostic system must be connected to the personalized learning environment.

4. Examples

To address the applications of CER model in more details, the cooperation of multiple experts/ teachers with several illustrative examples of constructing CER and presetting weight values between test item and related concepts is given in this section.

4.1 Constructing CER with the cooperation of multiple experts/ teachers

An expert system: Please consider concepts in “Computations and Applications of Quadratic Equations” unit.

Experts/ Teachers: Polynomial arithmetic, Factor theorem and multiple theorem, Factorization, Cross method, and Quadratic equation in one unknown.

An Expert system: Please consider the direction of concept relationships.

Experts/ Teachers: Assign the direction of concept relationships.

An Expert system: Integrate the corresponding relationships given by multiple experts as following condition:

- If all of the domain experts agree on the same prerequisite relationship direction, set this direction on constructing CER.
- If there are opposite opinions, that is, the domain experts have assigned the different prerequisite directions for two concepts, ask the experts to check and reconsider their opinion.

- If there are some experts who have assigned no prerequisite relationship and most of domain experts who have assigned the prerequisite relationship direction, set this direction on constructing CER based on most of domain experts' opinion.
- If there are some experts who have assigned the prerequisite relationship direction and most of domain experts have assigned no prerequisite relationship, set no relationship on constructing CER based on most of domain experts' opinion.
- If there is the same number of domain experts who have assign both the prerequisite relationship direction and no relationship direction, ask the experts to check and reconsider their opinion.

Experts/ Teachers: check and reconsider their opinion by using online or face-to-face discussion.

An Expert system: no further checking and considering

Testing and Diagnostic System linked with technological personalized learning environment:

Get a final CER which is then used to provide enhanced learning paths to individual students accordingly.

4.2 Presetting weight values between test item and related concepts with the cooperation of multiple experts/ teachers

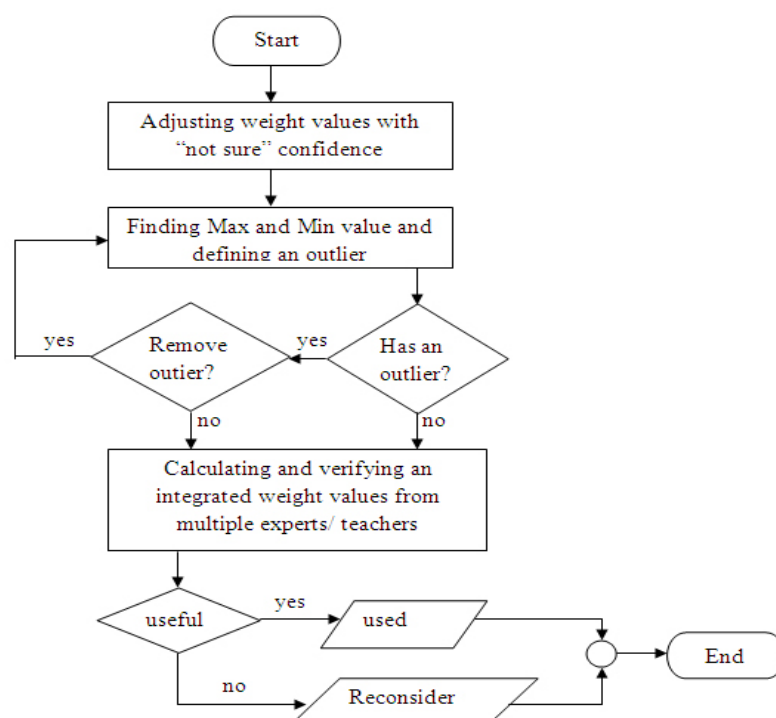
An expert system: Please determine weight values between related concepts in this test item: find X in $2X + 5 = 15$.

Expert/ Teacher A: Determine values 1 for concept "Equation" with sure

Expert/ Teacher B: Determine values 3 for concept "Equation" with not sure

Expert/ Teacher C: Determine no relationship for concept "Equation" with sure

An expert system: Integrate their opinion as follows:



Experts/ Teachers: check and reconsider their opinion by using online or face-to-face discussion.

An Expert system: no further checking and considering

Testing and Diagnostic System linked with technological personalized learning environment: Get a final weight value between related concepts in this test item which is then used to detect concept learning problem students accordingly.

5. Conclusion

Although CER model or concept-effect relationship model has attracted the attention of researchers in developing technological personalized learning environment area, the criteria for applying a CER model is still unclear, especially in constructing the CER and presetting weight values between test item and related concepts. In this paper, we have attempted to define the basic criteria when applying the CER model in technological personalized learning. Moreover, the strategies in the real classroom to conduct the technological personalized learning environment based on the CER model are clarified. In addition, it can be recognized that the cooperation of multiple experts/ teachers makes more precise in diagnosing conceptual learning problems and truthful conceptual learning suggestions to individual students during learning in technological personalized learning environment.

References

- Bai, S. M., & Chen, S. M. (2008a). Automatically constructing concept maps based on fuzzy rules for adapting learning systems *Expert Systems with Applications*, 35, 41–49.
- Bai, S. M., & Chen, S. M. (2008b). Evaluating students' learning achievement using fuzzy membership functions and fuzzy rules *Expert Systems with Applications*, 34, 399–410.
- Chen, C. M. (2008). Intelligent web-based learning system with personalized learning path guidance. *Computers & Education*, 51, 787–814.
- Chen, S. M., & Bai, S. M. (2009). Learning barriers diagnosis based on fuzzy rules for adaptive learning systems *Expert Systems with Applications*, 36, 11211–11220.
- Chen, L. H. (2011). Enhancement of student learning performance using personalized diagnostic and remedial learning system. *Computers & Education*, 56, 289–299.
- Cheng, S. Y., Lin, C. S., Chen, H. H., & Heh, J. S. (2005). Learning and diagnosis of individual and class conceptual perspectives: an intelligent systems approach using clustering techniques. *Computers & Education*, 44, 257–283.
- Chu, H. C., Hwang, G. J., Tseng, J. C. R., & Hwang, G. H. (2006). A computerized approach to diagnosing student learning problems in health education. *Asian Journal of Health and Information Sciences*, 1, 43–60.
- Günel, K., & Aşlıyan, R. (2010). Extracting learning concepts from educational texts in intelligent tutoring systems automatically. *Expert Systems with Applications*, 37, 5017–5022.
- Hwang, G. J. (2003). A conceptual map model for developing intelligent tutoring systems. *Computers & Education*, 40, 217–235.
- Hwang, G. J., Tseng, J. C. R., & Hwang, G. H. (2008). Diagnosing student learning problems based on historical assessment records. *Innovations in Education and Teaching International*, 45, 77–89.
- Hwang, G. J., Panjaburee, P., Shih, B. Y., Triampo, W. (2013). A group decision approach to developing concept effect models for diagnosing student learning problems. *British Journal of Educational Technology*, 44(3), 453–468.
- Kaburlasos, V. G., Marinagi, C. C., & Tsoukalas, V. T. (2008). Personalized multi-student improvement based on Bayesian cybernetics. *Computers & Education*, 51, 1430–1449.
- Lee, C. H., Lee, G. G., & Leu, Y. (2009). Application of automatically constructed concept map of learning to conceptual diagnosis of e-learning. *Expert Systems with Applications*, 36, 1675–1684.
- Ministry of Education (2002). *Curriculum of basic education (B.E. 2001)* (3rd ed.). Bangkok, Thailand: The Express Transportation Organization of Thailand.
- Panjaburee, P., Hwang, G. J., Triampo W., & Shih, B. Y. (2010). A multi-expert approach for developing testing and diagnostic systems based on the concept-effect model *Computers & Education*, 55, 527–540.
- Panjaburee, P., Triampo, W., Hwang, G. J., Chuedoung, M., & Triampo, D. (2013). Development of a diagnostic and remedial learning system based on an enhanced concept effect model. *Innovations in Education and Teaching International*, 50(1), 72–84.
- Wanichsan, D., Panjaburee, P., Laosinchai, P., Triampo, W., & Chookaew, S. (2012). A majority-density approach to developing testing and diagnostic systems with the cooperation of multiple experts based on an enhanced concept-effect relationship model. *Expert Systems with Applications*, 39, 8380–8388.

The Development and Evaluation of the Science Reading and Essay Writing System

Li-Jen WANG, Yu-An CHEN, Chen-Min LAI, & Ruo-Han CHEN, Ying-Tien WU*
Graduate Institute of Network Learning Technology, National Central University, Taiwan
*ytwu@cl.ncu.edu.tw

Abstract: Popular science reading and science essay writing are parts of the science inquiry activities which can facilitate learners to construct their science knowledge and develop science literacy in school. However, there are a great deal of difficulties and challenges for students to learn how to read popular science articles and write essays. Therefore, helping students read and write should be a crucial issue. Previous research has revealed the effectiveness of teacher community on teachers' professional development. This study developed a "Science Reading and Essay Writing System" (SREWS) as a platform for students to read popular science articles and write essays. After the development of the SREWS, system evaluations were also conducted. A total of 60 senior high school students participated in the system evaluations. The results showed that they expressed satisfactory perceived usefulness and ease of use of the system. Also, they expressed high willingness to use the SREWS. They also appreciated the usefulness and usability of the scaffolding functions of the system. Some suggestions and implications for system design, and future work are also discussed.

Keywords: Science essay writing, science reading, inquiry

1. Introduction

The main difference between popular science and normal science articles is that the former is easier to understand and more accessible for students. However, the main resource of learning science for students is through textbook. When students get older, without textbooks, they tend to lose the opportunity to read popular science articles. As a result, they do not have the skills to summarize the articles they read and then write essays. According to some research, popular science reading and science essay writing are parts of the science inquiry activities which can facilitate learners to construct their science knowledge and develop science literacy in school. Kao (2010) has mentioned that "no scientists can do experiments without knowing anything". That is to say, scientists also need to read relevant articles and write essays to explore scientific phenomenon. However, there are a great deal of difficulties and challenges for students to learn how to read popular science articles and write essays. Therefore, helping students read popular science articles and produce essays should be crucial. Previous research has revealed the effectiveness of teacher community on teachers' professional development. This study developed a "Science Reading and Essay Writing System" (SREWS) as a platform for students to read popular science articles and write essays. The purposes of this study are (1) Develop a platform for helping students read popular science articles and further write essays. (2) Evaluations of SREWS: its usefulness, usability, and willingness of using this platform.

2. System development

2.1 System Framework

The system framework of the SREWS is depicted in the following diagram (See Figure 1). As shown in Figure. 1, this system framework consists of eight main modules and three databases. The three

databases store popular science document data, mission, documents, and users database. The eight modules can be divided into two categories, teachers and students. For teachers, there are four modules which can help teachers upload popular science articles, monitor students, setting up missions, and managing students' data. For students, they can set up essay questions, manage their own essays and popular science articles uploaded by teachers, write their own essays, and finally interact with other students and teachers. Teachers and other students can vote or give comments in the interaction session. With the three databases and eight modules, teachers and students can work together to finish science reading and essay writing tasks.

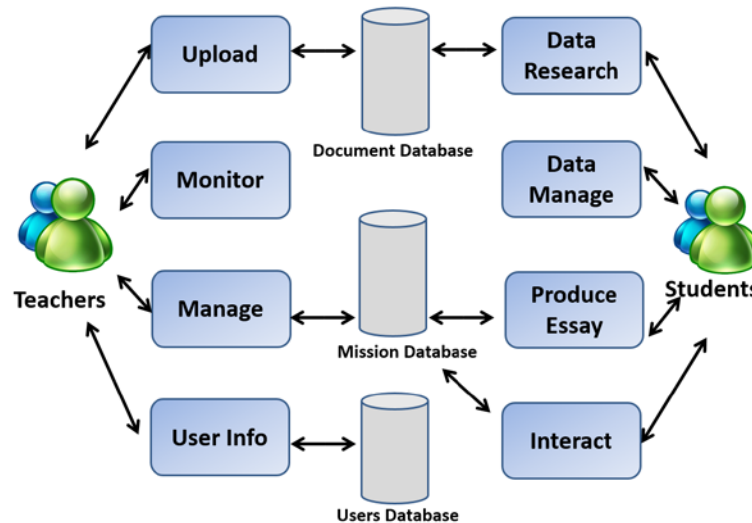


Figure 1. System framework of the SREWS

2.2 System Functions

The functions of the above system modules are further explained in the following table (See Table 1).

Table 1. Functions of the SREWS

Module	Description	Function	User
Upload	Teachers upload popular science articles to the database.	Upload popular science articles	Teacher
Monitor	Teachers can monitor students' status. Teacher can grade students' essays.	1. Monitor students' status. 2. Evaluate students' essays.	Teacher
Manage	Teachers can assign tasks to students	Setting up missions	Teacher
User Info	Teachers can add, edit, and delete students' data.	Manage students' database	Teacher
Produce essay	Students set up essay questions and edit their essays. (See Figure 2)	1. Setting up essay questions 2. Editing essays 3. Essay checklist	Student
Data research	Students can search popular science articles uploaded by teachers and save those articles they need. (See Figure 3)	1. Search articles 2. Save articles	Student
Data manage	Students can write notes or make comments on the saved articles. (See Figure 4)	1. Write notes 2. Make comments	Student

Interact	Students and teachers can grade or give comments on students' essays.	Voting and making comments on essays	Teacher Student



Figure 2: Setting up essay questions and editing page



Figure 3: Searching popular science articles uploaded by teachers and saving function.



Figure 4: Writing notes or making comments on the saved articles.

3. Methodology (System evaluation)

3.1 Participants

There were 60 participants in this study. They were senior high school students who volunteered to join 3 stages camp of popular science writing held by the research team. These students were then randomly divided into control group and experiment group. Their experience of writing science essay were also investigated (See Table 2)

Table 2. Grouping of participants

Experience of writing essay	Experiment Group	Control Group
Never	17	25
Once	12	3
Twice	0	3
Three times	0	1

3.2 Instruments

In this study, the participant students' perceived usefulness and usability of the SREWS as well as their willingness of using the SREWS were evaluated. In addition, the Scaffolding function of SREWS was also investigated. To this end, the 6 Likert-scale questionnaire developed in Phang, et al. (2009) was adapted and used in this study. The first modified instrument consists of three scales: the overall usefulness (4 items), usability (4 items), and willing of use (3 items). The second modified instrument consists of three scales: setting up essay questions (3 items), searching data (3 items), and arranging information (3 items)

The alpha reliability values of the three scales in the first instrument are greater than 0.9, and the overall alpha reliability value of the instrument is 0.95. In the second instrument, the overall alpha reliability value is 0.89.

3.3 Data collection

There were two stages of data collection. First, the authors collected the participant students' essay scores of pretest. Second, after the teaching activities of the camp, the authors collected participant students' essay scores again. Finally, the questionnaires developed and adapted in this study (the usefulness, usability, and willingness of using the SREWS and scaffolding function of the system) were also collected.

4. Major findings and Discussion

4.1 Major findings

The collected data were analysed quantitatively. Table 3 shows that the students' average scores on usefulness, usability, and willingness are between 5.01 to 5.13, which were higher than the 6 Likert scale average score (i.e., 3.5). It indicates that the participants in this study generally held positive attitude toward the system and were willing to use it.

Table 3. The overall results of system evaluation of SREWS

Criteria	Mean	S.D
Usefulness (4 items)	5.13	0.88
Usability (4 items)	5.01	0.85
Willingness (3 items)	5.08	0.81

Table 4 shows that the students' average scores on usefulness of scaffolding functions (setting up

essay questions, searching data, and arranging information) are between 4.68 to 5.17, which were also higher than the 6 Likert scale average score. It indicates that the participants in this study held positive attitude toward the functions of scaffolding provided by the system.

Table 4. The results of system evaluation of SREWS

Usefulness of Scaffolding functions	Mean	S.D
Setting up essay questions(3 items)	4.68	1.01
Searching data (3 items)	5.05	0.78
Arranging information (3 items)	5.17	0.78
Writing Essay (4 items)	4.91	1.02

4.2 Discussion

The aim of this study is to develop a platform which can help students read popular science articles and then write essays expressing their thinking. Most participants expressed satisfactory perceived usefulness and ease of use of the SREWS. Also, they had high willingness to use the SREWS in helping them write science essays. In addition, the scaffolding functions developed in this system also met their demand of science inquiry. In other words, the four scaffolding functions, setting up essay questions, searching data, arranging information, and writing essays, can help students go through the process of science inquiry and further finish science essay writing.

In the analysis of students' scores of essay before and after the learning activities in the three stages camp, we found out that the scores of control group have increased positively. Also, the data collected in this study also shows that the system can help students improve their essay writing skills. In the future system development, more functions of guiding essay writing will be suggested in order to help students produce essays with high quality and quantity.

Selected References

- Chamberlain, K, & Crane, C.C. (2009). *Reading, Writing, and Inquiry in the Science Classroom: grades 6-12*. Thousand Oaks, CA: Corwin Press.
- Cook, L. K., & Mayer, R. E. (1988). Teaching readers about the structure of scientific text. *Journal of Educational Psychology*, 80, 448-456.
- Hill, J. R. & Hannafin, M. J. (2001). Teaching and learning in digital environments: The resurgence of resource-based learning. *Educational Technology, Research and Development*, 49(3), 37-52.
- Hand, B., Prain, V., Lawrence, C. & Yore, L. D. (1999). A writing in science framework designed to improve science literacy. *International Journal of Science Education*, 10, 1021-1036.
- Heselden, R., & Staples, R. (2002). Science teaching and literacy, part 2: Reading. *School Science Review*, 83, 51 – 62
- Prain, V., & Hand, B. (1996). Writing for learning in secondary science: Rethinking practices. *Teaching and Teacher Education*, 12, 609-626.
- Quintana, C., Reiser, B. J., Davis, E. A., Krajcik, J., Fretz, E., Duncan, R. G., . . . Soloway, E. (2004). A scaffolding design framework for software to support science inquiry. *The Journal of the Learning Sciences*, 13(3), 337-386.
- Quintana, C., Zhang, M., & Krajcik, J. (2005). A framework for supporting metacognitive aspects of online inquiry through software-based scaffolding. *Educational Psychologist*, 40(4), 235-244.
- Quintana, C., & Zhang, M. (2012). Scaffolding strategies for supporting middle school students' online inquiry processes. *Computers & Education*, 58(1), 181
- Rivard, L. P. (1994). A review of writing to learn in science: Implications for practice and research. *Journal of Research in Science Teaching*, 31, 969-983.
- Yarden, A. (2009). Reading scientific texts: Adapting primary literature for promoting scientific literacy. *Research in Science Education*, 39, 307–31
- Yore, L. D. (2000). Enhancing science literacy for all students with embedded reading instruction and writing-to-learn activities. *Journal of Deaf Studies and Deaf Education*, 5, 105–121.

Effect of Simulation-based Inquiry with Dual-situated Learning Model on Change of Student's Conception

Niwat SRISAWASDI^{a*}, Sunisa JUNPHON^b & Patcharin PANJABUREE^c

^a*Faculty of Education, Khon Kaen University, Thailand*

^b*Chiangyuen Pittayakom School, Thailand*

^c*Institute for Innovative Learning, Mahidol University, Thailand*

*niwsri@kku.ac.th

Abstract. Numerous researches in science education have reported that many students displayed learning difficulties in understanding and hold unscientific conceptions about sound wave although sound is an everyday phenomenon that we constantly observe. Moreover, their common alternative conceptions about wave phenomena of sound are often resistant to change into correct physics of thought. To investigate effect of the teaching method of simulation-based inquiry with dual-situated learning model (SimIn-DSLM) on student's conceptual understanding of sound wave, 38 of Grade 11 secondary school students participated in learning physics with computer-simulated experiment. Both quantitative and qualitative data of conceptual understanding and conceptual change were collected, and analyzed aiming to understand their conceptual status at before, after, and a month after the use of SimIn-DSLM teaching method. The results showed that the method of SimIn-DSLM explicitly influenced their conceptions in physics of sound wave into correct physics. This finding suggests that the SimIn-DSLM method could be used to induce mechanism of change within students' conceptual knowledge of sound wave phenomena and the change of their conceptions could place them into meaningful conceptual framework of basic scientific knowledge.

Keywords: Computer simulation, open inquiry, dual-situated learning model, conceptual change

1. Introduction

In the past decades, science educators have widely studied alternative conceptions held by students at all levels and how to bring about process of change of their alternative conceptions into scientific conceptions. Many science education researchers have reported a critical important finding that students' alternative conceptions in science are highly resistant to change through undersign (conventional) classroom instruction (She, 2004). To account student's unscientific conception, new innovative instructional methods and media have, recently, been developed to solve the problematic issue in order to help students the learning of science concepts. However, there is still a lack of sufficient empirical study to support any instructional approach that would contribute to students' conceptual change. Conceptual change can be subdivided into differentiation in which new concepts emerge from more general concepts, class extension in which existing concepts become cases of another subsuming concept, and re-conceptualization in which nature of and relationship between concepts changes significantly (Dykstra, Boyle and Monarch, 1992). This study employed the Dual Situated Learning Model (DSLM) (She, 2003) to examine the changes in understanding of science concepts and it becomes the core subject of the present study. The DSLM developed by She (2003) has been carried out in order to reveal whether or not this model has positive effects in student's learning of science concepts and this model show that is very effective in grasping science concepts meaningfully and reducing misconceptions (She, 2002, 2003, 2004).

In the last few years, recent educational research has indicated that the structural mode (highly structured labs that provide questions, theory, and experimental and analytical procedures) of inquiry is not sufficiently effective for developing scientific performance in science learning (Srisawasdi, 2012a;

Zion and Sadeh, 2007), and engaging student into more flexible mode of scientific inquiry is more emphasizing in recent science education (Srisawasdi, 2012a; 2012b). Additionally, computerized technological tool is so commonplace in the practice and advancement of science education community, and computer simulation has been increasing into the context of science teaching, and also considered as a cognitive tool for student's learning in science. There is abundant evidence that computer simulation is critical to assist students' visualization of scientific phenomena and there has been associated with gains in scientific conceptual understanding among science students in areas (Srisawasdi, 2008). Based on the pedagogical practice of She's DSLM, various methods of instruction can use with the model. In this present study, instructional method of inquiry-based science incorporated with instructional media of interactive computer simulation was chosen to create a unique learning environment for student's science learning, called "Simulation-based Inquiry with Dual-situated Learning Model (SimIn-DSLM)" for student's science learning. Thus, this study uses the SimIn-DSLM to promote conceptual development of sound wave by enhancing process of conceptual change. Numerous difficulties in student's understanding of sound wave have been identified (Barman, Barman and Miller, 1996; Linder, 1987, 1992, 1993; Linder and Erickson, 1989; Maurines, 1992, 1993; Merino, 1998a, 1998b; Wittmann, 2001; Wittmann, Steinberg and Redish, 1999). Within sound wave as a topic, we decided to concentrate on its nature such as properties of and speed of sound wave for two reasons. It is the best defined problematic sub domain of sound wave, and it also promises the most in an attempt to find underlying principles that govern the set of alternative conceptions on sound wave phenomenon, especially its nature and property.

2. Theoretical Background

2.1 Dual-situated Learning Model (DSLM) for Science Learning

Over the past three decades, many instructional models for science learning were grounded on theoretical aspects of conceptual change. The DSLM is one of the models which facilitated the conceptual change theory. The DSLM (She, 2003, 2004) considers students' alternative conceptions to be a very important consideration in providing students the opportunity to be actively involved in the process of reconstructing their alternative conceptions and of moving toward a more complete and advanced scientific conception. She and Liao (2010) have detailed features of DSLM by emphasizing that the process of conceptual change, firstly, should be situated on the nature of science concepts and students' beliefs about these science concepts in order to determine which essential mental sets are needed to construct a more scientific view of the concepts. Secondly, probing students' beliefs about the particular science concept may achieve a deeper understanding of characteristics and causes of students' alternative conceptions, and providing the new mental set on the platform of which knowledge reconstruction can occur. Thirdly, the information on which and how many particular mental sets the students lack for restructuring the science concept would determine which and how many specific dual situated learning events need to be designed to supplement this deficiency and to foster conceptual change. The last feature provides an opportunity to challenge students to see whether they can actually apply the mental sets that they have revised or constructed to another situation, thus achieving a successful conceptual change.

2.2 Science Teaching with Computer Simulation

Computer simulations have become more widespread in science classroom. By contemporary definitions, computer simulation is a computer-based visualization technology which can imitate dynamic systems of objects in a real or imagined world supporting to the quality of the visual aids. Computer simulation has been used extensively as a visual representation tool to advocate presenting dynamic theoretical or simplified models of real-world components, phenomena, or processes, enlarging students to observe, explore, recreate, and receive immediate feedback about real objects, phenomena, and processes. There are several educational values that computer simulation adds into science learning activities (Hennessy, Deane and Ruthven, 2006), especially in activity type of inquiry-based science.

Now, technological developments such as computer simulations can implement more effective inquiry learning. Inquiry learning with computer simulations is learning through experimentation and scientific reasoning. Within simulations, students change variable values and observe effects to form conclusions. Through this process students discover principles, rules, and characteristics of scientific phenomena (de Jong, 2006).

2.3 Simulation-based Open-inquiry Science Learning

In recent years, more and more evidence indicates that structured inquiry, highly structured laboratory practices that provide questions, theory, experimental and analytical procedures, is not sufficient in developing scientific thinking (Zion and Sadeh, 2007). This type of investigation produces a robotic style of thinking that is less effective than teaching deductive reasoning, detailed in-depth thought processes, and logic (Srisawasdi, 2012a). According to the evidence, engaging learners into more flexible of scientific inquiry through conducting laboratory experiment is more emphasizing in recent science education. Therefore, science teachers who have a critical role in implementing inquiry-based learning, especially in case of open-ended inquiry, need to know and practice to build up increasingly open-inquiry science learning process for students. Recently, the meaning of open inquiry is quite not clear yet and inquiry practitioners are still discussing about its characterizations. Buck, Bretz and Towns (2008) described open inquiry in a way that can be used by both secondary school practitioners and university researchers as an investigation where instructor provides the inquiry question or problem and basic background, but the remaining characteristics are left open to the student, in where learners have to develop their own procedure, analysis, communication, and conclusions to address an instructor provided question.

According to Buck, Bretz and Towns (2008)'s idea, the learning process of open-inquiry science with computer simulation could possibly be proposed in a combination of open-inquiry components and computer-based inquiry activities, in order to creating a unique learning environment of open-inquiry learning with computer simulation technology, as display in Table 1.

Table 1: A matrix of simulation-based open-inquiry learning process for science laboratory learning

		Simulation-based laboratory component		
		Pre-lab	Laboratory	Post-lab
Open-inquiry component	Teacher	Open-ended Problem/Question		
		Basic Background/Theory		
	Student		Procedure/Design	
			Result analysis	
				Result communication
				Conclusion

3. Methods

3.1 Study Participants

The participants for this study included 38 of Grade 11 students in a local public school at Northeast region of Thailand. They were attending a physics course for basic education level and they were invited to participate in this research. The participants were aged 17-18 years. All of them did have satisfactory basic computer and information and communication technology skills but they had not any experience with using computer in physics learning before.

3.2 Domain of Conceptual Learning Events

Based on DSLM instructional procedures, there were seven of designed learning events of sound wave that used to cover students' alternative conceptions of the concept consisting of: reflection of sound wave (C_1); diffraction of sound wave (C_2); interference of sound wave (C_3); refraction of sound wave (C_4); speed of sound wave in different kinds of medium (C_5); and speed of sound wave in different temperature of medium (C_6).

3.3 Interactive Computer Simulation on Sound Wave Phenomena

In order to facilitate students' learning of sound wave concepts through the designed learning events as mentioned previously, interactive simulations on sound wave from Physics Education Technology (PhET) research group and Crocodile Physics were used as a conceptual tool for student's inquiry learning, as display in Figure 1. It is clear that students' common alternative conceptions of sound wave are due to the invisibility of amount involved and their nature, making it more difficult to construct concepts related to nature of sound wave. Therefore, the sound wave simulations was designed and developed on the common alternative conceptions held by students at all level, and emphasizes providing students with visualizations of the sound wave phenomenon to help them build more scientific views of property of sound wave and speed of sound wave concepts.

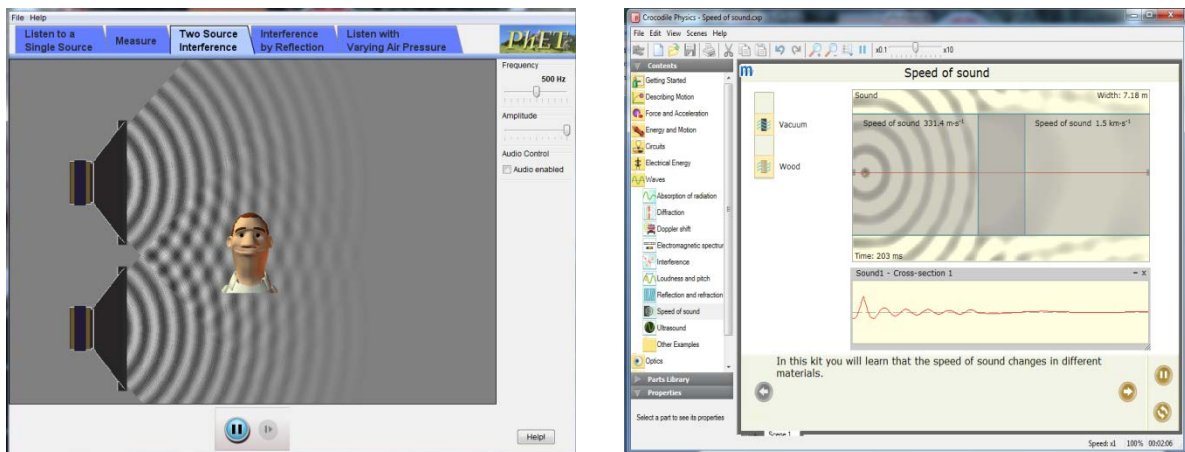


Figure 1. Illustrative interface examples of sound wave simulations from PhET (Left) and Crocodile Physics (Right)

3.4 Data Collection

For investigating students' conceptual change in this study, a series of open-ended question items was administered to examine their conceptual understanding before their attending with the SimIn-DSLM teaching method. The SimIn-DSLM method was implemented to them four three-hour weekly lecture in classroom and there were included seven conceptual learning events on sound wave phenomenon. After that, the same question items was administered to them again for exploring their exiting conceptual understanding and also investigate change of their conceptual understanding happened from the intervention. Moreover, the same question items, two months after the post-test, were administered to them for examining their conceptual retention. In addition, video and sound recorders were simultaneously used to collect students' discourse. Their conversational negotiations were both audiotaped and videotaped during their interacting with the SimIn-DSLM in class period. The audiotaped transcripts were used for the bulk of the transcripts, the videotapes provided additional information detailing students' expressing conceptual ideas as they reacted to the SimIn-DSLM during the class period.

3.5 Data Analysis

To investigate impacts of the SimIn-DSLM teaching method on students' conceptual change of sound wave phenomena, both quantitative and qualitative analysis methods were conducted to verify its impact. For analysis of students' conceptual understanding on sound wave phenomena, the content analysis was primarily used for writing protocol of their answers to each open-ended question item both pre-test, post-test, and retention test. For students' conceptual change analysis, the qualitative changes of their conceptual understanding between pre-test to post-test, and pre-test to retention-test, were measured and quantified into five categories (She & Liao 2010) including: (1) Progress (PG) - to what extent the student's conceptions improved; (2) Maintain-correct (MTC) - to what extent the student's conceptions were maintained correctly; (3) Maintain-partial correct (MTPC) - to what extent the student's conceptions were maintained as partially correct; (4) Maintain-incorrect (MTIC) - to what extent the student's conceptions were maintained as partially incorrect; (5) Retrogression (RTG) - to what extent the student's conceptions retrogressed. Each student's conceptual understanding in test was analyzed by percentage for PG, MTC, MTPC, MTIC, and RTG from pre-test to post-test, and then post-test to retention-test. In an effort to qualitative explain cognitive process of conceptual change during students' learning action, taxonomy of conceptual change (Dykstra, Boyle & Monarch, 1992) was placed on a template to analyze the change of the students' conceptual understanding, within their exiting conceptual framework. The taxonomy included (1) Differentiation (D) - wherein new concepts emerge from existing, more general concepts; (2) Class extension (CE) - wherein existing concepts considered different are found to be cases of one subsuming concept; and (3) Reconceptualization (R) - wherein a significant change in the nature of and relationship between concepts occurs. The students' discourse protocols were transcribed and reviewed and their conceptual framework were described on the template. Through comparison of the templates, the students' cognitive processes of conceptual change were identified.

4. Results

4.1 Characteristics of Conceptual Change

The percentage of the average quantity of type of conceptual change from pre-test to post-test, and post-test to retention-test are presented in Figure 2.

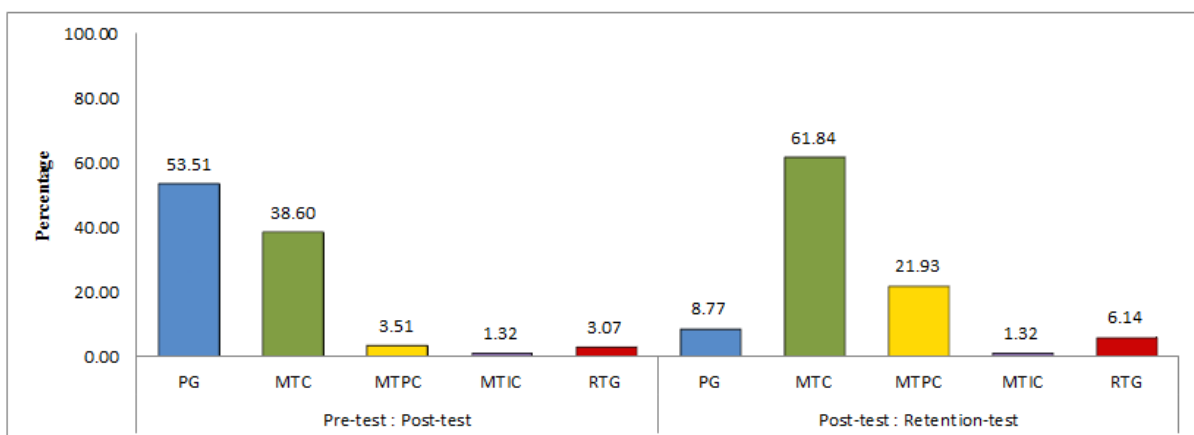


Figure 2. Distribution of conceptual change on sound wave phenomena among pre-test, post-test, and retention-test

As seen in Figure 2, there is the average percentage of change for students' understanding of sound wave from post-test to retention-test, and post-test to retention-test. For the transition of pre-test and post-test, the result shows that the average percentage of Progress (PG) (53.51%) and Maintain-correct (MTC) (38.60%) were the main category of conceptual change for students' conceptual understanding in sound wave. This indicates a potential of SimIn-DSLM teaching method

that most of students' conception (92.11%) have had acceptable scientific conception after interacting with the SimIn-DSLM. Nevertheless, there was, after the interacting, 4.83% of their conceptions still be alternative (unscientific) conception on sound wave and 3.07% of their conceptions had been retrogressed their own scientific conception into alternative conception. The result in considering to the transition of post-test and retention-test shows that 70.61% (8.77% of PG and 61.84% of MTC) of their conceptions have been reserved permanently in the status of acceptable scientific conception even two months after the last interaction with the SimIn-DSLM class. However, there was a number of students' conception that the change of their conception was not sustained (18.42%). Unfortunately, about 3.07% of their conception has been completely transformed into alternative conception in two months after the SimIn-DSLM class.

4.2 Cognitive Mechanism of Conceptual Change

Using Dykstra, Boyle and Monarch (1992)'s framework of conceptual change process, the following discourse is an example of student' conceptual mechanism of change during interacting with the SimIn-DSLM class. The following discourse protocol was identified by the Differentiation.

- [1] Student B: For our experiment, we are comparing speed of sound in -10 degree Celsius and -30 degree Celsius. Which one is going faster?
- [2] Student C: At -10 degree Celsius is faster.
- [3] Student A: No. The sound is going faster at -30 degree Celsius. Isn't it?
- [4] Student B: We should consider the experimental result that there showed its velocity. The speed of sound at -10 and -30 degree Celsius were 325 and 349 m/s respectively.
- [5] Student A: Is the greater number indicated faster move?
- [6] Student C: Umm... So, the sound movement at -30 degree Celsius should be listened firstly.

An example of this discourse protocol is demonstrated the cognitive process of Reconceptualization for conceptual change occurred in Student C. Initially, the Student C held an alternative conception that the speed of sound wave in a lower temperature environment is faster than higher temperature as seen in line 2. During their inquiry learning process with sound wave simulations, Student A has discussed and shared a scientific conception of speed of sound wave as illustrated in line 3. Moreover, Student B posed a critical suggestion in order to consider the speed of sound wave in the experimental data obtained from the simulation as seen in line 4. After and then the Student A could get some more scientific details of the reflection phenomenon. Finally, the Student C has totally changed his alternative conceptions about the speed of sound phenomenon into scientific conception as evidence showed in line 6.

5. Conclusion

This present study results reveal that incorporation of learning by simulation-based inquiry into the DSLM, called Simulation-based Inquiry with Dual-situated Learning Model (SimIn-DSLM), has potential on the development of students' conceptual understanding in science through the mechanical process of conceptual change on the physics of sound wave because this learning environment provide students opportunity to visualize the sound wave phenomenon resulting in help them change scientific views of property of sound wave and speed of sound wave concepts. Moreover, the change of their conception was a deep process of repairing students' alternative conceptions into scientific conception, called radical conceptual change. This implies that students can more quickly and efficiently recall correct scientific conceptions in order to conceptualize more advanced science concept once their conceptual change is successful. The result of this study came from only one school. Before using or generalizing, it should be tried on a large number of students with different backgrounds. This further demonstrates that the DSLM can be effective in fostering students' radical conceptual change in

simulation-based inquiry learning environment as well as in web-based learning environment or in the classroom.

Acknowledgements

I would like to thank Faculty of Education, Khon Kaen University, Thailand for supporting the contribution of this research in this conference.

References

- Barman, C., Barman, N., & Miller, J. (1996). Two teaching methods and students' understanding of sound. *School Science and Mathematics*, 96(2), 63-67.
- Buck, L.B., Bretz, S.L. & Towns, M.H. Characterizing the level of inquiry in the undergraduate laboratory. *Journal of College Science Teaching*, 38(1) (2008): 52-58.
- de Jong, T. (2006). Computer simulations - Technological advances in inquiry learning. *Science*, 312, 532-533.
- Dykstra, D. I., Boyle, F. C., & Monarch, I. A. (1992). Studying conceptual change in learning physics. *Science Education*, 76(6), 615-652.
- Hennessy, S., Deane, R. & Ruthven, K. (2006). Situated expertise in integrating use of multimedia simulation into secondary science teaching. *International Journal of Science Education*, 28 (7), 701-732.
- Linder, C. J. (1987). Tertiary physics: a case study in students' conceptions of sound. In J. Novak (Ed.), *Proceedings of the Second International Seminar: Misconceptions and Educational Strategies in Science and Mathematics* (Vol. 3, pp. 322-334). Cornell University, Ithaca, NY, USA.
- Linder, C. J. (1992). Understanding sound: so what is the problem? *Physics Education*, 27(5), 258-264.
- Linder, C. J. (1993). University physics students' conceptualizations of factors affecting the speed of sound propagation. *International Journal of Science Education*, 15(6), 655-662.
- Linder, C. J., & Erickson, G. L. (1989). A study of tertiary physics students' conceptualizations of sound. *International Journal of Science Education*, 11(special issue), 491-501.
- Maurines, L. (1992). Spontaneous reasoning on the propagation of visible mechanical signals. *International Journal of Science Education*, 14(3), 279-293.
- Merino, M. J. (1998a). Complexity of pitch and timbre concepts. *Physics Education*, 33(2), 105-109.
- Merino, M. J. (1998b). Some difficulties in teaching the properties of sounds. *Physics Education*, 33(2), 101-104.
- She, H.C. (2002). Concepts of higher hierarchical level required more dual situational learning events for conceptual change: A study of students' conceptual changes on air pressure and buoyancy. *International Journal of Science Education*, 24(9), 981-996.
- She, H.C. (2003). DSLM instructional approach to conceptual change involving thermal expansion. *Research in Science and Technological Education*, 21(1), 43-54.
- She, H.C. (2004). Fostering "radical" conceptual change through dual situated learning model. *Journal of Research in Science Teaching*, 41(2), 142-164.
- She, H.C., Liao, Y.W. (2010). Bridging Scientific Reasoning and Conceptual Change through Adaptive Web-based Learning. *Journal of Research in Science Teaching*, 47(1), 91-119.
- Srisawasdi, N., Kerdcharoen, T. & Suits, J. P. (2008). Turning scientific laboratory research into innovative instructional material for science education: Case studies from practical experience. *The International Journal of Learning*, 15(5), 201-210.
- Srisawasdi, N. (2012a). Introducing students to authentic inquiry investigation by using an artificial olfactory system. In K. C. D. Tan, M. Kim, & S. W. Hwang (Eds.) *Issues and challenges in science education research: Moving forward*, Dordrecht, The Netherlands: Springer.
- Srisawasdi, N. (2012b). Student teachers' perceptions of computerized laboratory practice for science teaching: a comparative analysis. *Procedia – Social and Behavioral Sciences*, (in press)

- Winberg, T.M., & Berg, C.A.R. (2007). Students' cognitive focus during a chemistry laboratory exercise: Effects of a computer-simulated prelab. *Journal of Research in Science Teaching*, 44(8), 1108-1133.
- Wittmann, M. C. (2001). The object coordination class applied to wavepulses: Analysing student reasoning in wave physics. *International Journal of Science Education*, 24(1), 97-118.
- Wittmann, M. C., Steinberg, R. N., & Redish, E. F. (1999). Making sense of how students make sense of mechanical waves. *The Physics Teacher*, 37(1), 15-21.
- Zion, M. & Sadeh, I. (2007). Curiosity and open inquiry learning. *Journal of Biological Education*, 41(4), 162-168.

Exploring the Effect of Worked Example Problem-based Learning on Learners' Web-technology Design Performance

Chun-Ping WU^{a*} & Hao Jie YONG^b

^a*Department of Educational Technology, TamKang University, Taiwan*

^b*Department of Educational Technology, TamKang University, Taiwan*

*cpwu303@gmail.com

Abstract: The process of creating media products, maximizing the merits of advanced interactive technology is very complex. Media producers are highly demand of their cognitive abilities to integrate multiple domains of knowledge, which may include graphic design, technology skills, and problem-solving skills. The problem-based learning strategy (PBL), starting learning with a real-world problem, has been frequently adopted to develop the competency of learners with a major in technology or media production. Despite the fact that PBL effects have been reasonably argued and empirically tested, its associated learning tasks may overload the learners. This paper, grounded on the cognitive load theory, aimed to investigate the effects of worked examples on learners' web-technology design skills. The web-technology design problem was chosen as the main problem for participants to explore during the PBL activity. A series of problems and associated worked examples were developed. Furthermore, a web-based learning system was created to engage participants in observing the problems, watching the examples and practicing solving the given problems. A pre-and-post experimental design was adopted to test the effect of worked-examples. 80 university students, with a major in instructional technology programs, were invited to participate in the study and were randomly assigned to one of the intervention conditions. The finding supported the positive effect of the worked example on enhancing learners' web-technology design performance.

Keywords: Web-technology design performance, worked-out examples, problem-based learning

1. Introduction

Designing media products, using diverse features of advanced interactive technology is a very complex process, which demands media producers' cognitive abilities to integrate graphic design knowledge, web-technology design skills, problem-solving skills, and so on. They have to use the knowledge and skills to analyze the problems and devote cognitive capabilities to identify the differences between those problems and problems they have solved in the past, and come up a better solution. Once they successfully solve the problems, they also have to integrate the knowledge and experience learned during the problem-solving process into their existing schema, which may serve as their knowledge base for dealing with another problem in the future (Bransford and Schwartz, 1999; Chi and VanLehn, 2007; Jonassen, 1997). Therefore, training of media producers should move beyond focusing on the technology knowledge or techniques. Facilitating them in synthesizing diverse skills to solve given problems and re-constructing their scheme during problem-solving process should not be ignored.

Problem-based learning (PBL) engages learners in reasoning through real-world problems (Hmelo and Evensen, 2000), emphasizes the process of solving the process and encourages them to synthesize and construct their own knowledge base. This strategy helps them to associate the learned concepts or techniques with their application in the workplace, thus leading to enhancement of learning

transfer (van Merriënboer, 2007; van Merriënboer and Kester, 2007; van Merriënboer, Kirschner and Kester, 2003). However, the learning tasks designed based on PBL might demand learners' intrinsic cognitive efforts to explore the knowledge elements associated with the given problem or task. Learners with less knowledge or lower cognitive capabilities might devote their attentions and efforts both to relevant and irrelevant information, which might exceed their limited cognitive capacity and thus, decreasing the positive learning effect of PBL (Sweller, 2010; Sweller, van Merriënboer and Paas, 1998).

Therefore, prior studies have suggested incorporation of worked examples as a scaffold into PBL to facilitate learners in managing their limited cognitive capacity to construct their schema (e.g. Ayres and Paas, 2009; Kirschner, Paas, Kirschner and Janssen, 2011; Renkl, 1997; Sweller et al., 1998). Despite the effects of worked-out examples have been evidenced in more well-structured learning tasks (e.g. Atkinson, Derry, Renkl and Wortham, 2000), few studies validated its effects in the ill-structured learning tasks, such as web-technology design. Therefore, the purpose of this study is to explore the influence of worked example problem-based learning, (WPBL) on university learners' web-technology design performance.

2. Literature Review

Problem-based learning (PBL) engages learners in problem representation, analysis, solutions creation and evaluation. In order to correctly interpret and process the PBL task, learners do not only need to understand the concepts represented in the problems, but also to think through the interrelationships among those elements. On one hand, this strategy, if adopted appropriately, could impose the germane cognitive load on learners, encouraging them to actively construct knowledge of their own. On the other hand, this strategy could impose heavy intrinsic and extraneous cognitive load on learners, which affects the learning effects (Sweller et al., 1998).

Two design issues need careful attention while designing and implementing PBL. First, as PBL encourages cooperative learning, perspectives of the cooperative learning theory as well as the cognitive load theory should be taken into consideration. The cooperative learning theorists proposed that the diversity among team members could help learners to approach the given tasks from multiple perspectives. Similarly, the cognitive load theorists argue that when working in a cooperative condition, the information necessary to carry out the task and its associated cognitive loads can be executed in the expanded working memory capacity constituted by that of all the team members (Kirschner, Paas and Kirschner, 2009). This expanded working memory capacity could imply the existence of less intrinsic cognitive load for each individual group member (Kirschner et al., 2009; 2010). At the same time, learners might need to devote more time and effort to communicating with their peers who have different cognitive abilities and schemata in order to reach a consensus on the shared workload, and thus co-construct group schema. This may then prevent groups from effectively carrying out the task, and even negatively affect learning, if it reaches a state of cognitive overload (Kirschner et al., 2009). Therefore, to reduce the extraneous cognitive load resulted from communicating with the peers, this study allowed the subjects to choose their partners to work with.

Second, the scaffolds, such as worked-out examples, designed to facilitate learners in effectively managing their cognitive capacity to construct their own schema of the learned content have gained increasing attention (e.g. Ayres and Paas, 2009; Kirschner et al., 2011; Renkl, 1997; Sweller et al., 1998). The worked-out examples guided learners to focus on the critical information of the given problems, excluding the irrelevant information, which could effectively decrease the extraneous cognitive load (Hübner, Nückles and Renkl, 2010; Paas and van Gog, 2006; Stark, Kopp and Fischer, 2011; van Gog, 2011; Wittwer and Renkl, 2010). Furthermore, it helps them to concentrate on schema activation by observing the problem-solving strategies and process presented in the examples, and to re-construct their own schema for solving the similar problems (Atkinson et al., 2000; Renkl, 2005; van Gog, Paas and van Merriënboer, 2004). Its positive effects on learning have been evidenced in science and mathematics learning under the context of well-structured learning tasks (e.g. Atkinson et al., 2000; Paas and van Merriënboer, 1994; Sweller et al., 1998). Additionally, its positive effects were supported in the domain of instruction theories (e.g. Hoogveld, Paas and Jochems, 2005), argumentation development (e.g. Schworm and Renkl, 2006) and so on.

However, providing worked-out examples does not guarantee students' effective utilization of cognitive capacity to interpret the examples and construct schema (Gerjets, Scheiter and Catrambone, 2004; Renkl, 1997). While solving an ill-structured problem, such as a web-technology design problem, reading the worked-out examples could impose learners cognitive load. Worked-out examples, which simulate experts' reasoning process and solutions, might guide learners to observing the given problems from macro perspectives and focus on the highly relevant information. However, learners may not be able to identify the important information embedded in the examples or they may encounter the difficulty in understanding the contents or strategies presented in the examples (Catrambone and Holyoak, 1989). Instead, it might be easier for learners to imitate the worked-out examples that only present the experts' solution steps. Reading such an example might not demand too many cognitive efforts. However, the examples, which over-simplify experts' problems solving process, may not benefit learners in grasping the critical reasoning points, thus affecting their ability to transfer learned skills to solve more complex problems. Therefore, it brings the needs to test whether the positive effect of worked examples could be generated to the context of learning ill-structured web-technology design skills.

3. Research Method

This study compared the effect of worked example problem-based learning with traditional problem-based learning on learners' web technology design performance. 84 university students, who have a major in instructional technology and passed the basic course of web-design, were invited for this study. All the subjects were asked to form a group of 2 and each group were randomly assigned to one of the two intervention conditions. The interventions were implemented in a series of workshop with the same facilitator, learning topics, web-technology problems, learning system and supporting materials except the instructional strategies (PBL vs. WPBL). Four subjects dropped out of the workshop because the workshop schedule conflicted with their personal meetings; therefore, only data of 80 subjects were included for analysis.

3.1 Research Design

Eighty university students participated in the pre- and post-test experimental study. The web technology design problem was chosen as the main problems for participants to explore during the study. A series of problems and associated worked examples were embedded in the web-based learning system, named EPRARS. The system allowed subjects not only to interact with the given problems by watching the problem scenarios, typing and uploading solutions but also to watch the worked-out examples. Furthermore, subjects' paths of observing the worked-out examples were recorded.

A training session was delivered at the beginning to ensure that the participants possessed the fundamental computer skills required for interacting with the given problems within the adopted learning system. After training, each participant accomplished the pre-test followed by one month workshop. During the workshop, subjects, working in a group, interacted with the system to solve a series of 8 web-technology design problems. Subjects in the worked-example PBL condition could watch the examples on their own pace before proceeding to practice applying the learned strategies to solve the similar problems. At the end, each participant accomplished the post-test.

3.2 Variables and Instruments

The intervention included two levels: the traditional PBL and WPBL. Both levels were structured into two stages: The first stage started with a real-world web-technology design problem. Subjects were asked to observe the problems, identify the web design techniques that are highly related to the problems and try to generate their solutions. Simultaneously an e-manual with several web technology skills listed was given to them as a learning resource. All the eight given problems were sequenced according to problem complexity and difficulty. The subjects were required to solve one before proceeding to the next one. At the second, stage, the subjects solved four more complex web design problems without the manual at hand. In regard with the WPBL intervention, each problem was

presented with a worked-out example, which contained three components. The example started with presenting key points for problem interpretation. This component exemplified how web-technology experts would interpret the problem, what key information might be relevant to the problem and how such information might influence ways to approach the problem. The second component simulated experts' thinking and solutions. That is, subjects could manipulate the solution options in every decision node and watch the demonstration of how the decision was turned into web design effects. The third component explained the impacts of each design decision. This component was designed to help subjects understand the rationale behind each decision taken during the design process.

The dependent variable, which refers to learners' web technology design performance, was assessed by the correctness of solving the given 5 web-design problems within 60 minutes. Additionally, the pretest, including 10 basic web-design skills, was administered to detect pre-existing differences between the two groups.

4. Results and Conclusions

4.1 Results

The descriptive statistics of the variables are listed in Table 1. It can be seen that the subjects in the worked-example PBL group performed better than those in the traditional PBL group. Also, it should be noted that the pre-test scores of the two intervention groups are different; therefore, to use the ANCOVA analysis technique to control the possible effect of the pre-test becomes necessary.

Table 1. Descriptive statistics of the web technology design performance

Variable	No.	Pre-test		Post-test	
		Mean	SD	Mean	SD
Traditional PBL	42	73.38	11.01	71.81	18.46
Worked example PBL	38	80.58	7.22	85.74	14.61
Total	80	76.80	10.18	78.42	18.05

ANCOVA analysis, using the pre-test scores as the covariate was conducted to examine whether the subjects engaged in the worked examples PBL condition performed significantly better than those in the PBL condition. The Levene's test was conducted to examine the homogeneity of the variances. The assumption of the ANCOVA was not violated ($F=.85$, $p=.35$). As can be seen in Table 2, the statistically significant difference in the post-test scores between the two intervention groups was supported by the ANCOVA result. ($F=8.27$, $p=.005$)

Table 2. ANCOVA results

Source	Sum of Squares	df	Mean Square	F	P-value	Partial Eta Squared	Observed Power ^c
Corrected model	4711.24 ^b	2	2355.62	8.63	.000	.18	.96
Intercept	3086.77	1	3086.77	11.30	.001	.13	.91
Pre-test	841.53	1	841.53	3.08	.083	.04	.41
Intervention	2259.73	1	2259.73	8.27	.005	.10	.81
Error	21030.31	77	273.12				
Total	517780.00	80					
Corrected Total	25741.55	79					

a. The dependent variable is web-technology design performance

b. R squared = .183 (adjusted R Squared = .162)

c. * < .05, ** < .001

4.2 Conclusions

This study evidenced the positive effects of the worked example PBL on enhancing learners' web-technology design performance. Specifically, the worked-out examples simulating experts' reasoning process with additional explanations on the rationale behind the decision helps learners not only to concentrate on the problem-solving process but also to transfer learned strategies to solve similar problems. Therefore, incorporation of well-designed worked examples into PBL is recommended. Furthermore, in the current study, the measurement of learners' web-technology design performance was limited to learners' abilities to solve a series of web design problems. Future research is suggested to explore whether the worked example PBL would help learners to transfer learned web-technology skills to develop a web-based product.

Acknowledgements

This paper was funded by the research grant from the National Science Council, Taiwan, ROC (NSC 100-2511-S-032-002). The author would like to thank research assistants, Chia-Lun Chang, Zi-Xuan Su, Pi-Han Lo, Li-Chun Huang, Kai-Feng Zheng for their assistance during the learning system design and data collection process.

References

- Atkinson, R. K., Derry, S. J., Renkl, A., & Wortham, D. W. (2000). Learning from examples: Instructional principles from the worked examples research. *Review of Educational Research*, 70, 181–214
- Ayres, P., & Paas, F. (2009). Interdisciplinary perspectives inspiring a new generation of cognitive load research. *Educational Psychology Review*, 21, 1-9.
- Bransford, J. D., & Schwartz, D. L. (1999). Rethinking transfer: A simple proposal with multiple implications. In A. Iran-Nejad & P. D. Pearson (Eds.), *Review of research in education*, Vol. 24 (pp. 61–100). Washington, DC: American Educational Research Association.
- Catrambone, R., & Holyoak, K. J. (1989). Overcoming contextual limitations on problem-solving transfer. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 15, 1147-1156.
- Chi, M., & VanLehn, K. (2007). Accelerated future learning via explicit instruction of a problem solving strategy. In R. Luckin, K. R. Koedinger, & J. Greer (Eds.), *Proceedings of the 13th International Conference on Artificial Intelligence in Education* (pp. 409–416). Amsterdam: IOS.
- Gerjets, P., Scheiter, K., & Catrambone, R. (2004). Designing instructional examples to reduce intrinsic cognitive load: Molar versus modular presentation of solution procedures. *Instructional Science*, 32, 33-58.
- Hmelo, C. E., & Evensen, D. H. (2000). Introduction. Problem-based learning: Gaining insights on learning interactions through multiple methods of inquiry. In D. H. Evensen & C. E. Hmelo (Eds.), *Problem-based learning: A research perspective on learning interactions*. Mahwah: Lawrence Erlbaum Associates Publishers.
- Hoogveld, A. W. M., Paas, F., & Jochems, W. M. G. (2005). Training higher education teachers for instructional design of competency-based education: product-oriented versus process-oriented worked examples. *Teaching and Teacher Education*, 21, 287–297.
- Hübner, S., Nückles, M., & Renkl, A. (2010). Writing learning journals: instructional support to overcome learning-strategy deficits. *Learning and Instruction*, 20, 18-29.
- Jonassen, D. H. (1997). Instructional design model for well-structured and ill-structured problem solving learning outcomes. *Educational Technology Research and Development*, 45(1), 65-94.
- Kirschner, F., Paas, F., Kirschner, P. A., & Janssen, J. (2010). Differential effects of problem-solving demands on individual and collaborative learning outcomes. *Learning and Instruction*, 21, p587-599.
- Kirschner, F., Paas, F., & Kirschner, P. A. (2009). A cognitive load approach to collaborative learning: United brains for complex tasks. *Educational Psychology Review*, 21, 31–42.
- Paas, F., & van Gog, T. (2006). Optimising worked example instruction: different ways to increase germane cognitive load. *Learning and Instruction*, 16, 87-91.
- Paas, F., & Van Merriënboer, J. J. G. (1994). Variability of worked examples and transfer of geometrical problem-solving skills: A cognitive-load approach. *Journal of Educational Psychology*, 86, 122–133.
- Renkl, A. (1997). Learning from worked examples: A study on individual differences. *Cognitive Science*, 21, 1–29.
- Renkl, A. (2005). The worked-example principle in multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 229–246). Cambridge, UK: Cambridge University Press.

- Schworm, S., & Renkl, A. (2006). Computer-supported example-based learning: When instructional explanations reduce self-explanations. *Computers & Education*, 46, 426–445.
- Stark, R., Kopp, V., & Fischer, M. R. (2011). Case-based learning with worked examples in complex domains: two experimental studies in undergraduate medical education. *Learning and Instruction*, 21, 22–33.
- Sweller, J. (2010). Element interactivity and intrinsic, extraneous and germane cognitive load. *Educational Psychology Review*, 22, 123–138.
- Sweller, J., van Merriënboer, J. J. G., & Paas, F. G. (1998). Cognitive architecture and instructional design. *Educational Psychology Review*, 10, 251–296.
- van Gog, T., (2011). Effects of identical example-problem and problem-example pairs on learning. *Computers & Education*, 57(2), 155–174.
- Van Gog, T., Paas, F., & Van Merriënboer, J. J. G. (2004). Process-oriented worked examples: Improving transfer performance through enhanced understanding. *Instructional Science*, 32, 83–98.
- Van Merriënboer, J. J. G. (2007). Alternate models of instructional design: Holistic design approaches and complex learning. In R. A. Reiser, & J. V. Dempsey (Eds.), *Trends and issues in instructional design and technology* (pp. 72–81). Upper Saddle River, NJ: Pearson/Merrill Prentice Hall.
- Van Merriënboer, J. J. G., Kirschner, P. A., & Kester, L. (2003). Taking the load of a learners' mind: Instructional design for complex learning. *Educational Psychologist*, 38, 5–13. .
- Van Merriënboer, J. J. G., & Kester, L. (2007). Whole-task models in education. In J. M. Spector, M. D. Merrill, J. J. G. van Merriënboer, & M. P. Driscoll (Eds.), *Handbook of research on educational communications and technology*, (pp. 441–456, 3rd ed.). Mahwah, NJ: Erlbaum/Routledge.
- Wittwer, J., & Renkl, A. (2010). How effective are Instructional Explanations in Example-Based Learning? A Meta-Analytic Review. *Education Psychology Review*, 22, 393–409.

How to Construct an Assessment System for Engineering Courses

Yu-Hur CHOU^{a*} & Hsin-Yih SHYU^b

^a*Department of Information Management, TungNan University, Taiwan*

^b*Department of Educational Technology, Tamkang University, Taiwan*

*yhchou@mail.tnu.edu.tw

Abstract: Most test items used for engineering courses are application problems with a serial of calculations and logical adjustments. Mistakes of the parent (front) calculations may inherit to their child (rear) calculations. Teachers spend too much time in administering the examination. Therefore, the purpose of this article is to specify how to design and construct an assessment system with partial credit function for the engineering courses. Applying concept-mapping technique along with Petri-Nets and Goldsmith's closeness index theory, this system can inferential diagnoses in order to investigate examinee's misconceptions and produce the reasonable scoring for engineering courses.

Keywords: Computer-assisted assessment, Partial credit, Petri-nets

1. Introduction

Learning and teaching engineering in university level is not an easy job, since the knowledge structure on engineering is complex and may not be well defined. Therefore, it becomes a challenge or probably inappropriate to use the traditional tests, such as multiple-choice, fill-in-blank, or short essay type questions for assessing students' achievement. Most traditional tests are dichotomously scoring that fail to detect the thinking process of how students solve the problems. Instead, they only reflect students' response in last step. Such a traditional test ignores the importance of student's problem-solving performance in multiple steps, and neither provides the analysis of students' misconceptions in the process. In contrast to the dichotomously scoring, the polytonality scoring instruments are able to provide more accurate and valid assessment in engineering courses (Muraki, 1992, p. 160). Therefore, most engineering faculty in university favors the polytonality tests. However, there are some limitations for using the polytonality tests. First, they have to be administered manually, and take much more time. Second, teachers are still hard to describe students' misconceptions due to the limitation of teachers' memory. Therefore, the purpose of this research is to specify how to design and develop an assessment system to meet the needs of tests and measurements in the engineering courses. Three useful designed tactics are adopted in this research. First, the concept mapping technique is used as the format of reply sub-system. Second, a rule-based Petri-net module representing the logic structure of correct answer is proposed. Third, the fuzzy mapping technique is used to calculate the score of test and diagnose students' misconceptions.

The proposal assessment system includes the following functions and features:

- (1) This assessment system holds a dynamical parameter function, which can change the numeric components of items randomly, to prevent students from memorizing the answers (Hwang, 2003). The test items are changed automatically by following the adjustment of test concepts.
- (2) The concept mapping is used for representing the examinee's answers. Concept mapping is the technique of drawing a concept map to illustrate the structure of knowledge. There are some applications of the concept mapping techniques in education, such as the assessment and diagnosis of learning effect, the analysis of the learning path, and the representation of knowledge (Anderson, 1995). Examinee must draw the concept map and answer the calculation results for the testing topic. By using the concept mapping technique, it is easy to obtain enough information to investigate examinee's misunderstandings and to inference for diagnosis (Laffey & Singer, 1997, p. 368).

- (3) The Petri-Nets have been developed to describe information-processing systems that are characterized as being concurrent, asynchronous, distributed, parallel and stochastic (Molloy, 1989). It is adequate to generate test items dynamically, and has many advantages for representing the calculating structure of the testing concepts.

By using the Goldsmith's closeness index (Goldsmith, Johnson & Acton, 1991, p. 92), a calculating logic is developed for the scoring and diagnosis. This article demonstrates the proposed assessment system, not only can give student's grade fairly, but also can make the inference to examine examinee's misconceptions. This proposal system can be a useful tool to assist teacher's teaching and student's practice.

2. System Design

In this section, the system design is described and a test subject (rectangular reinforced concrete beam analysis with single layer bar, Reinforced Concrete, Civil Engineering) is selected to explain the designed procedures for developing this assessment system. The diagram of calculating procedures for selecting subject is shown in Figure 1. The general testing item is: Derive the nominal flexural resisting moment (M_n) of a rectangular RC beam with single layer bar. The given parameters are yield strength of reinforcement (f_y), compressive strength of concrete (f'_c), width of rectangular beam (b), area of tension reinforcement (A_s) and effective depth of rectangular beam (d). Three types of beams (balanced section, over-reinforced section and under-reinforced section) can be identified (Nawy, 1996).

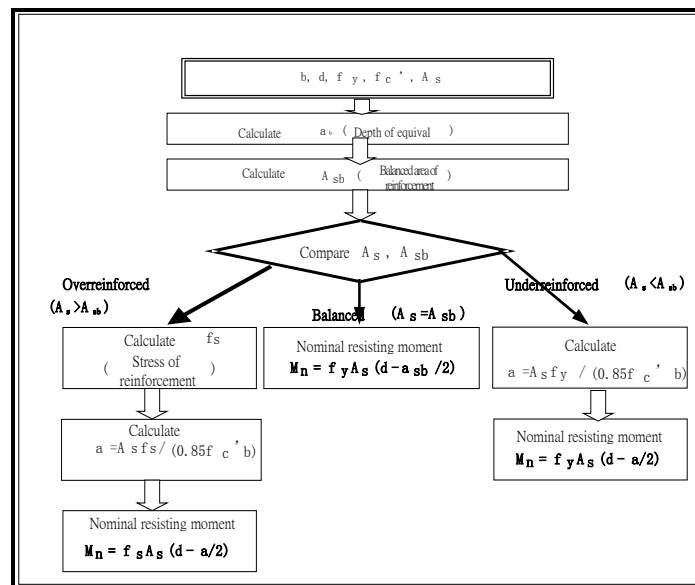


Figure 1. The calculating procedures for selecting subject.

The designed procedures are illustrated as follows:

Defining subject's concepts: The first design step is to define the subject's concepts. There are twenty-one concepts ($C_j, j = 1 \sim 21$) are derived from multiple experts for selecting subject.

Defining subject's calculation formulas: After analysis, there are 22 calculation formulas ($Q_i, i = 1 \sim 22$) for selecting subject.

Evaluation between concepts and formulas: In this step, we develop the relationship between formulas and concepts.

Construct the logic structure of solution: The basic design of Petri-Net includes four sets, are transitions (T), places (P), input relation (I) and output relation (O), then the quadruple $PN = (P, T, I, O)$ is called a Petri-Net. After over 30 years' development, the typical application domains include

industrial processes, business process modeling, hardware design, communication protocols and parallel programs etc. By utilizing the strong point of Petri-Net, we purpose a Rule-based Petri-Net to construct the logic structure of solution for test subjects. Figure 2 shows a unit of the Rule-based Petri-Net. There are four sets (parameters, calculating function, output arc and input arcs) for each unit. Parameter that links up input (output) arc is an input (output) parameter. Parameter can be a member of input, output or both parameters. The operating rules are:

- (1) The calculating function is fired, when all input parameters are known numbers.
- (2) After calculating function firing, the output parameter is calculated and is known.
- (3) A calculating function can be fired only once.

For the example in Figure 2, the total tensile force (T) is measured and is known, when the area of reinforcement (As) and the stress of reinforcement (fs) are known.

The purposed Rule-based Petri-Net is represented as Figure 3. There are four different sets in this net system. Because some parameters are both input and output parameters that makes ordering links between different calculations. This net system can represent concurrency and synchronization. Therefore, it is very adequate to construct the logic structure of solution.

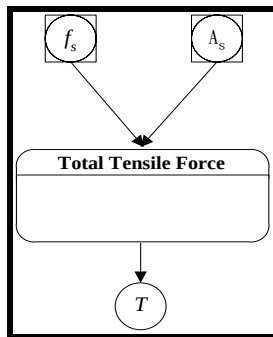


Figure 2. An independent unit.

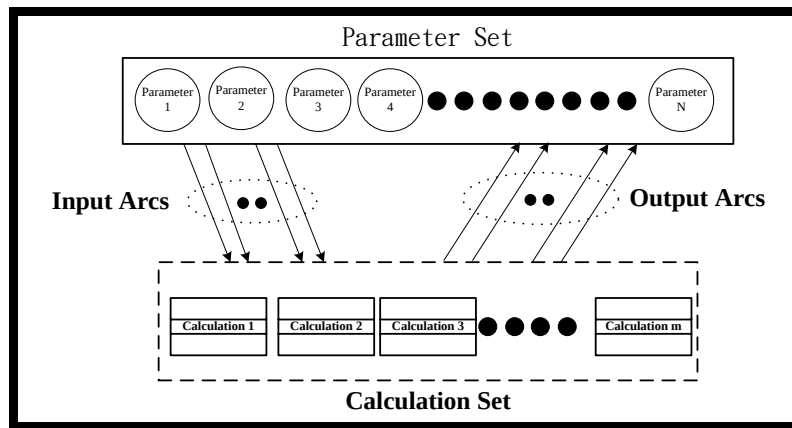


Figure 3. The model of the Rule-based Petri-Net.

3. Test items generator

In our purposed assessment system, test items can be changed automatically by following the adjustment of test concepts. The Petri-Net structure is used to develop the test items generator. An example shown in Figure 4 is used to explain the algorithm of test generator. This example is a logic structure of solution that is represented by Petri-Net. There are 4 concepts (C), 6 calculations (Q), 12 parameters (P) and 18 arcs in this Petri-Net.

- (1) If the selecting test concepts are concepts 1 and 3, system will find the relative calculations (Q_1 and Q_5) by mapping.
- (2) From the selecting calculations (Q_1 and Q_5), system will process the relationship checking to find test calculations between selecting calculations. After relationship checking, the test block (rectangular area in figure 4) is found and 5 testing calculations ($Q_1 \sim Q_5$) are confirmed.
- (3) From the diagram of test block, 5 given parameters (P_1, P_2, P_3, P_6 and P_{10}) and 1 decoded parameter (P_{11}) are verified.
- (4) Test items generator will provide the values of given parameters and ask examinee to calculate the decoded parameter.

Partial scoring function: The system uses two mechanisms to estimate the score. The first one utilizes Goldsmith's closeness index (GCI) to measure similarity between correct concept map and examinee's concept map. The second one is the correct rate of calculations (CRC). By using both GCI and CRC, the final score is calculated likes (1) as follows:

$$Score = WC \times GCI + WS \times CRC \quad (1)$$

Where

Score: Final score.

GCI: The value of Goldsmith's Closeness Index.

CRC: The value of Correct Rate of Calculations.

WC: Weight of GCI (0~1).

WS: Weight of CRC (1-WC).

Goldsmith's closeness index (GCI): Goldsmith's method is used to compute the closeness index and the computing processes. The steps involved are listed as follows:

- Determine all sub-nodes $N = N1 \cup N2$.
- For each sub-node (n_i) belonging to N
 - ◆ Locate its first-order neighbor sets.
 - ◆ Compute the intersection, $I^{(i)}$ and the union, $U^{(i)}$.
 - ◆ Calculate the closeness coefficient, $C^{(i)} = I^{(i)} / U^{(i)}$.
- Compute the closeness index, $C(H1, H2) = 1 / \sum C^{(i)}$. The value of C ($H1, H2$) represents the closeness index.

An example for GCI comparison is shown in Figure 5. The comparison between teacher ($H2$) and examinee ($H1$) is made.

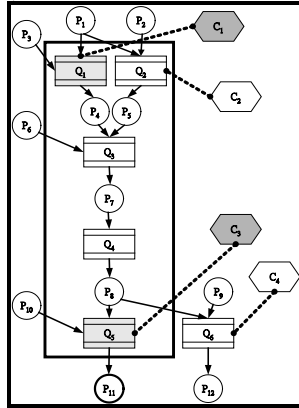


Figure 4. Example's Petri-Net.

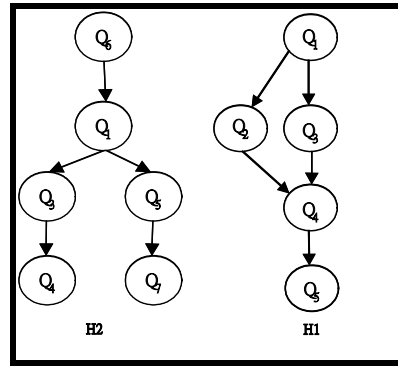


Figure 5. Example for GCI comparison.

Correct rate of calculations (CRC): The CRC is to investigate the result for each calculation. There are a series of calculations within a test item for many engineering courses. Mistakes of the parent calculations may inherit to their child calculations. Therefore, the system's judgment for each calculation is divided into six levels.

Misconception evaluation: From the result of equation 2, we can find the complete rating value for each test calculation. After referring the table of evaluation between concepts and calculations, the examinee's misconceptions can be investigated.

$$CRV^{(i)} = WC \times C^{(i)} + WS \times P_i \quad (i = 1 \sim m) \quad (2)$$

Where

$CRV^{(i)}$: The Complete Rating Value of calculation i .

$C^{(i)}$: The closeness coefficient of calculation i .

3. System Illustrations

This assessment system is developed on the Windows platform, written by Visual Basic. It uses MS Access as the database system. It has four sub-systems (modules): Test Items Generator, Concept-Mapping Reply Sub-system, Answering Evaluator and Diagnostic Evaluator, are explained as follows:

Test Items Generator (TIG): The TIG can build test items automatically by following the selecting test concepts and style. The values of the testing variables are generated randomly. Therefore, the same testing problem will be shown within different variable values for different tests. The answering evaluator will calculate the correct answers correspondingly. The diagnostic evaluator will then trace the processes of the user's operations and identify the users' misconceptions.

Concept-Mapping Reply Sub-system (CMRS): The CMRS employs an examinee's reply environment using the concept mapping technique. Examinee must draw the concept map and answer the calculation results for each calculating step for the test subject. CMRS can record all examinee's operations for evaluation.

Answering Evaluator (AE): The AE obtains the problem's correct answer.

Diagnostic Evaluator (DG): The DG diagnoses users' problem solving skills.

The operation of this assessment system is divided into four steps that are (1) select the testing subject; (2) select the test concepts and style; (3) reply and (4) view the diagnostic result.

The system's entry screen is to select the test subject shown in figure 6. After test subject is selected, the test concepts and style must be assigned shown in figure 7. Three different test styles (independent, partial combination and complete combination) can be selected.

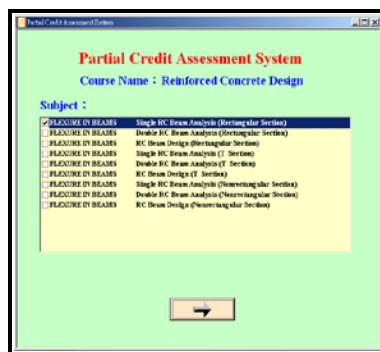


Figure 6. Select test subject.

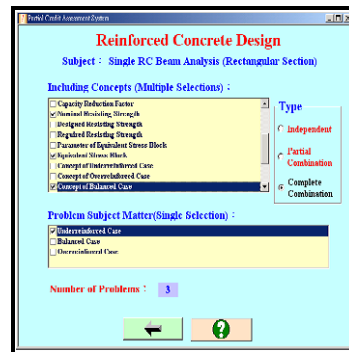


Figure 7. Select concepts and style.

The description of test item is shown in figure 8, the values of given parameters are assigned by computer randomly. The answering evaluator is shown in figure 9. It can show the correct calculating procedures and correct value for each calculation step by step.

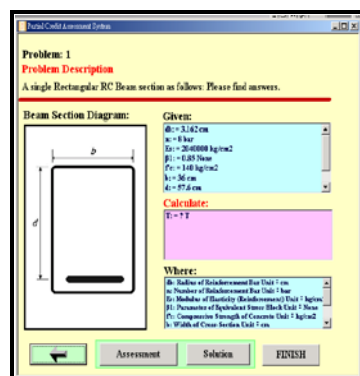


Figure 8. Problem's description.

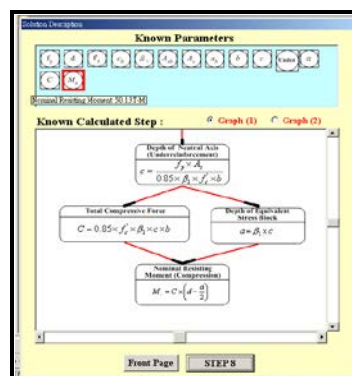


Figure 9. Answering evaluation.

Figure 10 shows the concept map reply sub-system. Examinee can reply his or her answers by using the concept mapping technique. Figure 11 shows the assessment results. It contains the problem's description, correct answering procedures and examinee's answering procedures.

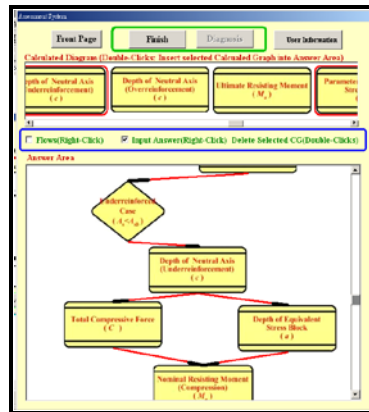


Figure 10. Concept map reply sub-system.



Figure 11. Assessment results.

3. Conclusions

This research develops a partial scoring assessment system. This system adopts the dynamic state to make out test items. The values of the testing variables are generated randomly. Therefore, the same testing problem will be shown within different variable values for different tests, to prevent students from memorizing the answers. We also purpose a Rule-based Petri-Net model for building the structure of answer logic and it can match the dynamic pattern and random parameters completely. This system adopts concept-mapping environment as examinee's reply system, can acquire enough information to investigate examinee's misconceptions and measure final score by using partial scoring strategy.

The objective courses of this system are within design procedures, logic reasoning and accounts. Many engineering courses are matching these conditions. In regard to the field of civil engineering, many courses, such as reinforced concrete design, steel design, pavement design, concrete proportioning design etc., agree on demands. This assessment system, not only can give student's grade fairly, but also can make the inference to examine examinee's misconceptions. This system can be a useful tool to assist teacher's teaching and student's practice.

The standalone version was finished. Now, we are developing the network version. In the future, we will actually practice and test this system in class, to improve system's functions with solid experiences and extend this system to universities or colleges, to save the teachers' time for grading paper examinations.

References

- Anderson, J.R. (1995) Cognitive Psychology and its Implication, New York: Freeman and Company.
- Chen, S., Lin, S., and Chang, K. (2001) Attributed Concept Maps: Fuzzy Integration and Assessment, IEEE Trans. on Systems, Man, and Cybernetics. Part B: Cybernetics, 31(5), 842-852.
- Goldsmith, T., Johnson, P., and Acton, W. (1991) Assessing structural knowledge, Journal of Educational Psychology, 86, 88-96.
- Hwang, Gwo-Jen. (2003) A Test-Sheet-Generating Algorithm for Multiple Assessment Requirements, IEEE Transactions on Education, Vol. 46, No. 3, August.
- Laffey, J. M. and Singer, J. (1997) Using Mapping for Cognitive Assessment in Project-based Science, Journal of Interactive Learning Research, 8(3-4), 363-387.
- Molloy, M. K. (1989) Petri Net Modeling – The Past, the Present, and the Future, Proceedings of the Third International Workshop on Petri Nets and Performance Models, Dec. 11-13, Kyoto, Japan.
- Muraki, E. (1992) A Generalized Partial Credit Model: Application of an EM Algorithm, Applied Psychological Measurement, 16(2), 159-176.
- Nawy, Ed. (1996) Reinforced Concrete: A Fundamental Approach, Englewood Cliffs, New Jersey: Prentice Hall,.

Adaptive Question Generation for Student Modeling in Probabilistic Domains

Nabila KHODEIR* & Nayer WANAS

Informatics Dep., Electronics Research Institute, Egypt

*nabila_khodeir@yahoo.com

Abstract: Problem solving behavior remains to be the most trustable source for modeling student knowledge in intelligent tutoring systems. In this work we focus on diagnostic problem solving, as an essential question type associated with probabilistic domains. Student answer for such questions indicates the knowledge discrepancies between the student and his/her stored model. In this paper we introduce an algorithm that adaptively generates different appropriate follow-up questions to accurately determine the knowledge discrepancies in the student model. Answers to these follow-up questions are used to update the student model. Verification is conducted on the updated model based on the matching between student and generated model answers to the presented questions. Results suggest that tracking the student knowledge discrepancies using the generated follow-up questions improves the prediction accuracy of the student answers by 20% compared to relying only on the diagnostic questions alone. In addition, approximation of the student model enhanced by 40% relative to that obtained using the diagnostic questions alone.

Keywords: Intelligent Tutoring System, Student Modeling, Abduction, question generation

1. Introduction

Intelligent Tutoring Systems (ITSs) (Brusilovsky, 2003), are computer-assisted tutoring systems that build a model for the objectives, preferences and knowledge of an individual student in order to adapt the system to his/her learning needs. Based on the student model ITSs are able to support the student with a lot of interactions and personalization. Modeling of the student knowledge drew heightened attention in the literature (Carmona et al., 2005), (Pahl and Kenny, 2009). Several models have been suggested for the student knowledge modeling namely the i) Overlay model, ii) Perturbation model and iii) Differential model. The overlay model represents the user model as a subset of the expert model (Carmona et al., 2005), (Melis and Siekmann, 2004). Therefore, its modeling process is basically based on the representation of the expert or the domain model. Several representations have been adopted for the overlay model including production rules (Corbett et al., 1993), and Bayesian Networks (BN) (Conati et al., 2002). The perturbation model extends the overlay model by adding the representation of the student incorrect knowledge (misconceptions or bugs) (Yacef, 2005). The differential model, on the other hand, represents both the student knowledge and the differences between student and expert knowledge (the knowledge the user lacks) (Burton and Brown, 1976). We invoked the idea of a differential model to utilize the differences between the student model answer and the student answer to update the student model. The student model is initialized based on some assumptions or prior information, and in some cases could be initialized as the expert model, In turn the answer generated from the model prior to matching the student perfectly can be different from the student answer to the presented question. Such differences express the discrepancies between the student knowledge and the student model. The contribution of this paper is an algorithm that utilizes such discrepancies to automatically generate a series of follow-up questions, and in turn the student answers to these questions are used to update the student model.

Most adaptive tutoring systems that model the student knowledge deal with domains represented by deterministic models that define the domain by a set of variables and describe the relations between them by fixed rules. However, in the real world, especially in applications such as forecasting, troubleshooting and medical diagnosing, a degree of uncertainty is inherent which requires

the use of probabilistic models to represent such domains. Domains of this nature are probability based inference in complex networks of interdependent variables. Bayesian Networks are widely used approach to represent such domains to handle the uncertainty of their relations. (Suebnu kam and Haddawy, 2005) presented an example of modeling the student knowledge in probabilistic domains. They suggested a modeling algorithm that focuses on the skill of reasoning through domain variables relations around practical patient problems in medical domains. This work suggests a modeling algorithm that utilizes diagnostic skill to infer the student knowledge in probabilistic domains through different questions that are automatically generated.

Automatic generation of questions supports the functionality of ITSs, in addition to dialogue systems (Piwek, Stoyanchev, 2010), and Question Answering (QA) systems (Kalady et al., 2010). Most question generation techniques revolve around linguistic study including syntactic and semantic analysis for the given document to generate questions (Heilman and Smith, 2009), (Becker et al., 2010). In turn, factual and definitional questions are the common types of generated questions in these approaches (Heilman and Smith, 2010). However, queries associated with some domains cannot be generated or answered based on linguistic analysis. For example, Probabilistic domain represents a difficult problem in this regard. In this paper we proposed an approach to generate different questions types and their answers automatically by utilizing the Bayesian Network (BN) knowledge representation (Korb and Nicholson, 2011) for probabilistic domains.

The rest of this paper is organized as follows. Section two presents the proposed different questions types and their generation process. The proposed updating technique is illustrated in section three. Thereafter, we explore the experimental results that illustrate the performance evaluation of the algorithm implementation in section four, and discussion of the result and conclusion is given in section five.

2. Proposed Questions Types and Their Generation Techniques in Probabilistic Domains

We identify three questions types that vary in the level of thinking required to be answered according to Bloom's Taxonomy (Bloom, 1956). Diagnostic and comparison questions, which belong to the higher thinking level, and feature specifications question, that belongs to the lower thinking level. Next section illustrates the different questions types in more details.

2.1 Proposed Questions Types

Probabilistic domains are usually associated with diagnostic questions which require identifying the most probable explanation given a set of evidences. We consider such questions as the essential questions especially in relation to ambiguous cases, where more than one hypothesis that explains the question evidences exists. In such cases the student is asked to provide a ranked list of possible hypotheses for the question evidences. Diagnostic questions for ambiguous cases are chosen since answers for such questions reveal more information about the student knowledge. Answer for such question need recalling of information, information analysis, and judgment skill to select and arrange the most possible hypotheses.

Comparison questions are used as follow-up questions to track the student beliefs about the relations strengths between specific evidence and different hypotheses. On the other hand, feature specifications questions are used to pursue what the student think about the relations existence between specific hypothesis and different evidences.

2.2 Questions Generation Contexts and Techniques

The modeling process relies on discrepancies between the student answer and answer generated from his/her model to diagnostic question. Each diagnostic question deals with a specific sub-graph in the

domain that is represented by a BN. The diagnostic question generation process is preceded by choosing some evidences that are have common relations with a set of hypotheses. These evidences constitute the generated question which is validated to have more than one hypothesis to achieve the condition of ambiguity case. Thereafter, the question is presented to the student to get his/her answer in addition to generating the question answer by applying abduction inference mechanism on the BN that represent the student model (Nilsson, 1998). An example of diagnostic question is presented in Figure 1.

Diagnostic Question	
If you have a case with maculopapular rash, abdominal pain, and malaise. What are the most probable diseases? Choose and Rank from the following diseases beginning by 1 to the highest likely diagnosis?	
☐ Rubella	☐ Roseola infantum
☐ Infectious mononucleosis	☐ Scarlet fever
☐ Measles	☐ Chicken pox

Figure 1. Example of diagnostic question

The answer provided by the student to the diagnostic question is compared to that generated by the student model using the abduction algorithm. If the answers match, we declare that the student model doesn't require regulation. On the other hand, if there is a discrepancy between the model and student answers the student model needs to be regulated. Then, generation of follow-up questions begins by analyzing the difference(s) between the two answers. Since the answer is a ranked list of hypotheses, the difference between the two answers can be one of the following:

1. One or more missing hypothesis.
2. One or more extra hypothesis.
3. Answers are presented in a different order.
4. Combined error of missing and extra hypotheses in a correct or incorrect order.

The follow-up questions generation process proceeds in two phases. First, check the missing and extra hypothesis and generates feature specifications question that ask about the existence and absent of relations between evidences and the missed or/and extra hypotheses. According to the student answer the student model is regulated. Fig. 2 gives example of the generated scaffolding questions according to the differences between the two answers.

Main Question If you have a case with maculopapular rash, and high fever, what are the most probable diseases? Student Answer: 1. Roseola infantum 2. Measles 3. Infectious mononucleosis Student Model Answer: 1. Roseola infantum 2. Scarlet fever 3. Measles	First follow up question Infectious mononucleosis is associated with 1. Maculopapular rash 2. High fever 3. None of the above Second follow up question Scarlet fever is unassociated with 1. Maculopapular rash 2. High fever 3. None of the above

Figure 2. Answers Differences and corresponding Generated Scaffolding Questions

After the student model is regulated the matching between the student answer and generated student model answer is checked. The second phase of the follow-up questions is initiated in the case of a mismatch between the two answers with regard to the order of the correct hypotheses. The generated follow-up questions in this phase are comparative questions which needs higher thinking skills

compared to the first phase, where the student is asked to compare between two hypotheses in regard of question evidences. Based on the student answer the student model is updated. Fig. 3 gives an example of the generated comparative questions in the second phase.

3. Updating Techniques

The student model is initialized by the expert model that represents some pediatric diseases from the medical domain in the form of a BN. According to the student answer, the student model is updated to give the same response as the student. Three different approaches for updating process was suggested i) coarse, ii) refined, and iii) blended (Khodeir et al., 2012). The coarse updating technique is based on sharp actions in updating of the student model BN. On the other hand, the refined updating is based on repetitive regulation of the student model BN gradually until matching between student answer and model answer occurs. Regulation will be terminated if the difference between the answers increases or the weights reach the threshold values which are zero for decreasing weight regulation and one for increasing weight regulation. Blended updating technique is adaptable way for student model regulation. According to the difference between the student answer and the model answer the updating model is selected. Missing or adding of hypotheses triggers coarse updating technique while wrong order difference initiates the refined updating technique.

Main Question If you have a case with maculopapular rash, and high fever What are the most probable diseases? Student Answer: 1. Roseola infantum 2. Measles 3. Infectious mononucleosis Student Model Answer: 1. Roseola infantum 2. Infectious mononucleosis 3. Measles	First follow up question Measles is less associated than Roseola infantum with 1. Maculopapular rash 2. High fever 3. Non of the above Second follow up question Measles is more associated than Infectious mononucleosis with 1. Maculopapular rash 2. High fever 3. Non of the above Third follow up question Infectious mononucleosis is less associated than Measles or Roseola infantum with 1. Maculopapular rash 2. High fever 3. Non of the above

Figure 3. Answers Differences and corresponding Generated Scaffolding Questions

3.1 Coarse Updating Technique

The coarse update is conducted by adding or removing of relations for the differences in the hypotheses in the following manner

3.1.1 Missing hypothesis or hypotheses

The student model is regulated by establishing missing relations or modifying the weight of the existing relations $P(H_i|E_j)$ between evidence E_j and the missed hypothesis H_i for each question. Different selected weights are allocated to each established relation. The weights of the newly added links are equal to the weight of the matching or nearest matching between the rank of the missing hypothesis $P(H_k|E_j)$. In case of absence of other relations, the weight is assigned to be equal 0.5. This is expressed by Equation 1.

$$P(H_i|E_j) = \begin{cases} P(H_i|E_j) & \text{if } P(H_k|E_j) \neq 0 \text{ and } (H_i)_{rank} \geq (H_k)_{rank} \\ 0.5 & \text{if } P(H_k|E_j) = 0 \end{cases} \quad (1)$$

3.1.2 Extra hypothesis or hypotheses

The student model is regulated by removing the existing relations $P(H_i|E_j)$ between the hypotheses added and the question evidence. This is expressed by Equation 2.

$$P(H_i|E_j) = 0 \quad \text{if } P(H_k|E_j) \neq 0 \quad (2)$$

3.2 Refined Updating Technique

The refined update is performed using successive increase or decrease in the weights and prevalence using a fixed step. The step value indicates the speed of settling of the algorithm. The linear refined modification is shown in Equation 3.

$$W_{i+1} = W_i \pm \Delta W_i \quad (3)$$

Where W_{i+1} is the new weight, W_i is the old weight, and ΔW_i is a constant value which is increased gradually by step equal to 0.1 with considering of the weight value is within the range [0,1].

In turn, the refined update increases the relations' weights between the hypothesis with the lowest rank and the evidence. In addition, the weights of the relations between the hypothesis with the highest rank and the evidence are decreased. If incremental updates fail to achieve a match through available iterations (until the updating weights reach a threshold value) the student model is updated by increasing the prevalence of the hypothesis with the lowest rank and decreasing the prevalence of the hypothesis with the highest rank.

3.3 Blended Updating Technique

The blended updating technique is a combination of coarse updating and refined updating techniques. Coarse updating is used when the student answer is heavily skewed from the student model answer in presence or absence of the hypotheses themselves. This is due to the fact that the student answer in this case is highly diverse from the model answer and needs significant modification. On the other hand, refined updating is used when the student answer differs from the student model answer in the order of hypotheses. This stems from the fact that the student answer in this case is in close proximity to the student model answer and needs limited modification. Figure 4 illustrates an example of the student model blended updating where the updating step in refined technique is equal to 0.2.

It is worth mentioning that updating techniques are applied on two cases. The first case relies on the student answers to diagnostic questions alone. In this case, blended updating technique is applied. Coarse updating is applied on all relations between the missing and extra hypotheses in the student model answer and the mentioned evidences in the question in addition to applying of the refined technique on erroneously ordered hypotheses. Refined updating techniques are used to update all relations between the wrong order hypothesis and the question evidences. On the other hand, the second case is based on the student answers to follow-up questions. This case is characterized by selectively updating relations between hypotheses and the question evidences according to the student answers to the presented questions. Coarse updating is used to update the student model according to feature specifications questions answers while refined updating is utilized for compare questions answers. Measuring the impact of the two cases on the modeling process is the target of the evaluation section.

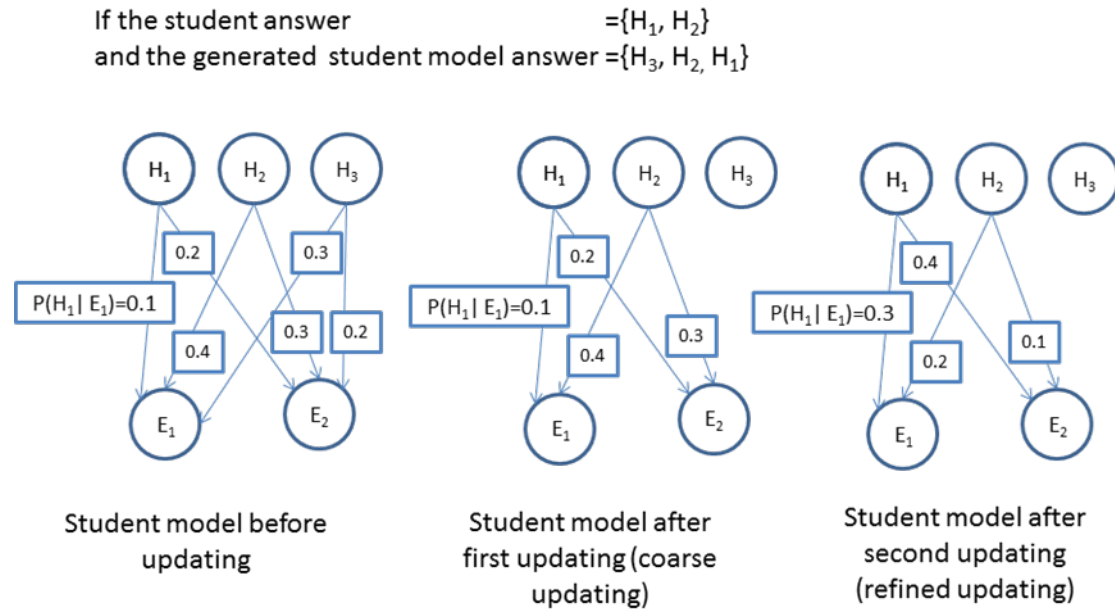


Figure 4. Illustration of Modification in case of Combined Error in the Generated Student Model Answer Using Blended Updating Technique

4. Evaluation

The accuracy of the student model using diagnostic questions and follow-up questions were evaluated from two perspectives: its ability to predict the outcome of an individual student answer implying its misconceptions and the approximation of the student model compared to the actual model. Measuring the approximation requires to run the experiment on students whose prior knowledge could be accurately assessed. This allows comparison between the resulted student knowledge model and the actual student knowledge. Therefore we use a simulated student approach in the evaluation process. (Van Lehn and Jones, 1998), and (Millan, et al., 2002) have suggested simulated student approaches for evaluating student models. Simulated students enable the measurement of the difference between the simulated student and the updated student knowledge model obtained quantitatively.

The proposed mechanism to generate the simulated students is based on an existing domain BN. Simulated students' models are randomly modified BNs that represent the students' knowledge. The simulated student response is assessed by processing the generated BN to generate the target student answer on the posted question. Simulated students BNs that represent the students' knowledge are automatically generated by perturbation of the knowledge model. The perturbation proceeds on two levels; 1) the links level, where some links are removed and some are added, and in 2) the weight level where some links weights values are changed. The perturbation process is constrained by specific ratios to prevent generation of an extremely perturbed BN that might be unrealistic. In this work, the medical domain is used as an example of probabilistic domains. The domain knowledge selected for evaluation is based on information from pediatric experts. Six diseases are selected based on their overlapping symptoms to allow generation of diagnostic questions. The relations between diseases and symptoms have causal relations with probabilities in addition to the prevalence of each disease are represented as a Bayesian Network. This representation is exploited to update the student model. Moreover it is utilized to verify the updating of the student model.

We aim to measure the impact of using generated follow-up questions on the efficiency of the student knowledge modeling process. We test the performance of the modeling algorithm using diagnostic questions, in addition to the effect of using follow-up questions. The blended updating technique is used in the both cases. The evaluation begins by generating three groups of twenty random different diagnostic questions. The diagnostic questions are used for the updating algorithm. Then, a different set of twenty questions are tested against the new updated student model for measuring the student answer prediction accuracy using the diagnostic questions *SPADQ*.

The same diagnostic questions are used to evaluate the updating algorithm by using follow-up questions. Mismatching between the student answer and generated student model answer initiate the generation of follow-up questions according the differences between the two answers. The follow-up questions are used for the updating algorithm. Another set of twenty questions are tested against the new adjusted model for measuring the student answer prediction accuracy using follow-up questions SPA_{FQ} . Prediction accuracy expresses the comparison between the student answer and the generated answer using the final updated student model. It is worth mentioning that, applying the refined technique proceeds by steps. Different updating steps (0.1,0.2 to 1) were used in measuring the prediction accuracy.

Figure 5 indicates enhancement of the performance of the algorithm using follow-up questions over using diagnostic questions by up to 20%.

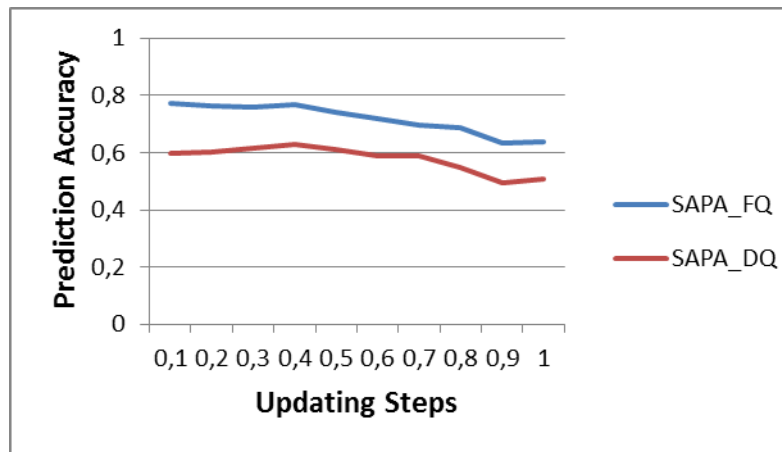


Figure 5. Prediction accuracy using follow-up questions SPA_{FQ} and prediction accuracy using the diagnostic questions SPA_{DQ}

It is worth mentioning that, the performance degrades for all updating techniques with the increasing of step size. This stems from the fact that, for larger steps the algorithm follows coarse actions instead of refined actions which lead to degradation of the performance.

To evaluate the approximation of the student model in the two cases (using diagnostic questions only and using diagnostic and follow-up questions) relative to the actual student model, we used the Root Mean Squared Error (RMSE) between the different models. RMSE is applied on the data that represents the differences in weights between the BN that represent the student model and the BN that represents the simulated student. The results show how using follow-up questions enhances the accuracy of the student model up to 40%. As shown in the following table the RMSE is significantly decreased in case of follow-up questions.

Table 1. RMSE for the differences between the student model and the actual model through different updating steps

Updating Steps	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Using diagnostic questions	9.38	9.34	9.24	9.15	9.30	9.11	9.46	9.31	9.93	9.98
Using follow-up questions	5.78	6.12	6.00	6.04	6.50	6.55	6.98	7.26	8.12	8.20

5. Discussion and Conclusion

In this paper, we presented an algorithm to approximate the student model in a probabilistic domain. The algorithm utilizes generated follow-up questions that track the discrepancies between the student knowledge and his/her knowledge model. The algorithm is invoked when the student answer mismatches the expected answer evaluated using the student model. The blended updating approach is applied in the modeling process. In addition, different granularity levels are evaluated by changing the

value of the updating step and the output of this parametric study is indicated. An experimental evaluation of the approaches has been conducted. Random models for the student are generated. A series of twenty questions are automatically generated and presented to the system based on the domain structure. The performance of the algorithm is evaluated using both the prediction accuracy of the student answers to the questions and the number of required trials to this estimation. The results suggested that using follow-up questions gives better performance with respect to accuracy compared to using diagnostic questions alone especially in small updating step by 20%. In addition, approximation of the student model enhanced by 40% relative to that is obtained using the diagnostic questions.

The algorithm aims to obtain a more accurate student knowledge model that contains the correct and incorrect knowledge represented in BN form. Then, the model can be used to control tutoring system, such as Intelligent Tutoring System, interactions with the student to rectify his/her errors. The proposed follow-up questions can be also used in the context of learning by utilizing the discrepancies between the student knowledge model and domain model.

References

- Becker, L. Nielsen, R., Okoye, I., Sumner, T., & Ward, W. (2010). What's next? Target Concept Identification and sequencing. *Third Workshop on Question Generation*, 35–44. *The Tenth International Conference on Intelligent Tutoring Systems (ITS2010)*, Carnegie Mellon University, Pittsburgh, Pennsylvania, USA.
- Bloom, B. (1956) Taxonomy of Educational Objectives. David McKay Co. Inc.
- Brusilovskiy, P. (2003). Adaptive and intelligent web-based educational systems. *Artificial Intelligence in Education*, 13, 159–169.
- Burton, R., and Brown, J. (1976). A tutoring and student modeling paradigm for gaming environments. In: *SIGCSE-SIGCUE joint symposium on Computer science education*, (pp. 236-246). ACM.
- Carmona, C., Milán, E., and Pérez de-la Cruz, J. (2005). Introducing prerequisite relations in a multi-layered Bayesian student model. In: L. Ardissono, P. Brna, & A. Mitrovic (Eds), *Proceedings of UM 2005* (pp. 347–356). LNAI, Springer-Verlag Publishers.
- Conati, C., Gertner, A., & Vanlehn, K. (2002). Using Bayesian networks to manage uncertainty in student modeling. *User Modeling and User-Adapted Interaction*, 12, 371-417.
- Corbett A., Anderson, J., & OBrien, A. (1993). The predictive validity of student modeling in the act programming tutor. In: Artificially AI-ED 93,(pp. 457-464).
- E. Millan, J. Perez-De-La-Cruz, & Luis. (2002). A bayesian diagnostic algorithm for student modeling and its evaluation. *User Modeling and User-Adapted Interaction*, 12, 281-330
- Heilman, M., Smith, N. (2009) Question generation via overgenerating transformations and ranking. *Technical Report CMU-LTI-09-013*, Carnegie Mellon University.
- Heilman, M. & Smith, N. (2010) Extracting Simplified Statements for Factual Question Generation. *Third Workshop on Question Generation*, 35–44. *Tenth International Conference on Intelligent Tutoring Systems ITS2010*, Carnegie Mellon University, Pittsburgh, Pennsylvania, USA.
- Kalady, S., Elikkottill, A., Das, R. (2010). Natural Language Question Generation Using Syntax and Keywords. *Third Workshop on Question Generation*, 1-10. *Tenth International Conference on Intelligent Tutoring Systems (ITS2010)*, Carnegie Mellon University, Pittsburgh, Pennsylvania, USA.
- Khodeir, N., Wanas, N., Darwish, N., & Hegazy, N.: Bayesian Based Student Knowledge Modeling in Intelligent Tutoring Systems. (2012). *38th Annual Conference of the IEEE Industrial Electronics Society*, 12-17, Montreal, Canada.
- Melis, E., & Siekmann, J (2004). Activemath: An intelligent tutoring system for mathematics. In: Rutkowski, L., Siekmann, J., Tadeusiewicz, R., & Zadeh, L. (Eds), *Seventh International Conference Artificial Intelligence and Soft Computing (ICAISC)*. LNAI, vol. 3070, (pp. 91-101). Springer-Verlag.
- Nilsson, D. (1998). An efficient algorithm for finding the m most probable configurations in probabilistic expert systems. *Statistics and Computing*, 8, 159-173.
- Pahl, C., & Kenny, C. (2009). Interactive correction and recommendation for computer language learning and training. *IEEE Transaction On Knowledge And Data Engineering*, 21, 854-866.
- Piwek, P., Stoyanchev, S. (2010). Question Generation in the CODA project. *Third Workshop on Question Generation*, 29–34. *The Tenth International Conference on Intelligent Tutoring Systems (ITS2010)*, Carnegie Mellon University, Pittsburgh, Pennsylvania, USA.
- Suebunukarn, S., & Haddawy, P. (2005). Modelling individual and collaborative problem solving in medical problem-based learning. *User Modeling 2005*, 377-386. Phonix, Arizona, USA.
- VanLehn, K., & Jones, R. (1998) Student modeling from conventional test data: A bayesian approach without priors. *Proceedings of 4th International Conference ITS98*, (pp. 434-443). Berlin Heidelberg: Springer Verlag,

Facilitating Creative Cognition by Embodied Conversational Agents

Yugo HAYASHI^a

^a*Faculty of Library, Information and Media Science, University of Tsukuba, Japan*
hayashi.yugo.gp@u.tsukuba.ac.jp

Abstract: The study investigated the use of collaborative embodied conversational agents in the facilitation of creative cognition. Based on preliminary studies, two factors were investigated through an experimental design addressing the number of conversational agents (single vs. dual), and method of communication (voice vs. text). 18 participants engaged in a simple interpretation game with embodied conversational agents. Role-playing embodied conversational agents made suggestions on the quality of the participant's interpretations. The study focused on how the two factors enhanced the quality of cognitive process during interactive activities with the agent. Analysis showed that the synergy created by the use of multiple agents along with a voice communication enhanced the cognitive process for the quality of creative interpretations. These results suggest that the number of agents and the method of communication are important factors in designing effective embodied conversational agents in creative activities.

Keywords: Embodied conversational agents, meta suggestions, creative cognition, communication media, social influence

1. Introduction

Past studies in HCI has pointed out the effective usage of embodied conversational agents (ECA) for facilitating learning such as providing meta cognitive suggestions and posing questions (Holmes, 2007; Kim, Baylor & Shen, 2007; Hayashi, 2012 a; Hayashi, 2013 a; Hayashi 2013 b). Recently, there is also a big concern on developing effective collaborative systems during creative activities (Dennis & Williams, 2003). It is a new challenge for ECA researchers to develop such innovative systems for facilitating creative cognitive process. To develop such effective systems, there are needs to implement findings in the field of creative cognition and psychology to design such effective systems (Finke, Ward, & Smith, 1992; Smith, Ward, & Schumacher, 1993). Taken all this, the present study will focus on the use of role-playing ECA's for effective interaction based on models of creative cognition. Especially, the present study will experimentally investigate the two factors (number of ECA's and media type) that are pointed out as effective factors for facilitating interpersonal interaction.

1.1 Creativity model in this study

Studies in cognitive psychology have attempted to understand the cognitive process of creativity. Across the studies, the cognitive model Geneplore has been one of the most reliable means of understanding creative cognition (Finke, Ward, & Smith, 1992). This model posits that creativity is composed of two cognitive processes: (1) a generative phase, in which an individual constructs mental representations, and (2) an exploratory & revise phase, in which those representations are interpreted and used to generate new creative ideas. Figure 1 shows the illustration of the creativity process model in the present study. The interpretative portion of the exploratory phase in the Geneplore model plays an important role in reinforcing ideas, self-reflections, and self-regulation. The quality of a self-generated idea is somewhat dependent on the ability to objectively interpret and evaluate the idea. Studies higher-level cognition such as problem solving show that internal biases, such as a conformation bias occur

as negative constraints (Jhonson-Laird, & Wason, 1977). People tend to search for evidence that supports their own hypotheses or expectations.

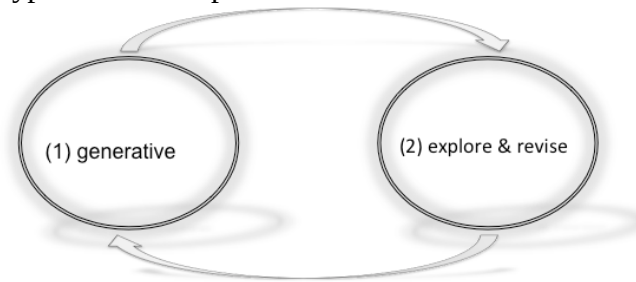


Figure 1. The creativity model in this study.

It is also known that people favor to use knowledge that is accessible to his/her prior knowledge. In creative activities, it is well known that such bias appears and blocks cognitive actives. For example, Smith, Ward, and Schumacher (1993) pointed out the effect of conformity during creative thinking. They used the term fixation to refer to a block or impediment to the successful completion of various types of cognitive operations. For example, fixation can obstruct the retrieval of familiar names or words, such as the names of famous celebrities or politicians. The way that fixation can cause such blocks can also limit the success of creative-idea generation tasks such as divergent thinking and brainstorming. They conducted an experiment about idea generation, in which participants were asked to invent new toys. Prior to the task, one-half of the participants saw three examples of toys that were attributed to fictitious previous participants. Although the three examples were different from each other, each had three critical features in common. The participants who saw the examples used the same critical features, which is indicative of the conformity effect. This study suggests that the when individuals are facing a situation requiring new interpretations, they tend to utilize their available knowledge. To avoid such a bias, it is important to facilitate metacognition, the ability to look at an instance or idea objectively and critically.

Studies of collaborative problem solving in cognitive science have presented results that collaborative partners can play an important role in facilitating the meta-cognitive Okada & Simon, process, which can help avoid cognitive biases (Hayashi, 2012 a). This occurs because feedback from others about the generated interpretations provides an opportunity to rethink the interpretation in a more reflective way (Miyake, 1986; Okada & Simon, 1997). In the present study, it focuses on the type of interaction where a participant generates multiple ideas and is then prompted to make improvements to them. Such interactive activity is an effective strategy in facilitating a objective perspective.

In creative tasks, meta-cognition is important to the formation of better interpretations. However, collaborative activities are costly in terms of manpower, and it is difficult arrange meetings at times that suit all collaborators. To overcome such difficulties, the study focus on the use of ECA as co-partners. The challenge of the study is to investigate the possibility of using these agents in collaborative activities, and discover their potential for increasing the quality of creative cognitive process.

1.1.1 Using multiple ECA's

It is a big challenge for HCI researchers to design an effective ECA that are useful to become peer-collaborators. When considering collaborative activities where conducting creative cognitive activities with agents, it is important to understand the effective presentations towards humans. It is therefore a big concern on understanding that factors on what kind of interactions and designs of agents are useful for influencing human behaviors. Some studies in social psychology has pointed out the effects of 'co-presence' of partners during collaborative activities. It is pointed out that if individuals are experienced in performing a task or expect

they can perform the task well, working in the presence of others impairs performance (Dennis & Williams, 2003). It is hypothesized that the more the number of the members increase, the more the presence may become stronger and thus facilitate task performance. Then how will the factors such as the increase of the members influence such kind of social facilitation during interaction with an ECA?

Social psychology research has demonstrated the impact of the group dynamics on task performance (Levine, Resnick, & Higgins, 1993). Studies focusing on persuasive communication have shown that the number of other collaborators may influence an individual's decisions. A few studies of human-computer interaction investigated the impact of social pressure from embodied agents. For example, Lee, & Nass (2002). examined the impact of visual representations of multiple agents on performance in a social dilemma task. Beck, Wintermantel & Borg (2005) investigated how social relationships with multiple agents may affect persuasion. Also past studies of the author's studies has investigated the influence of multiplicity during creative cognition (Hayashi, 2012 b; Hayashi, in press). However there are not so many studies that investigate the influence of cognitive process during interactions with such ECA's. These studies imply that under some conditions, agents could motivate and facilitate a change in human opinions. Therefore, agents may play an important role in facilitating differing perspectives through social influence during creative cognitive activities.

1.1.2 Effective communication media

An important point of the interaction with an ECA is the media type, or the method of communication (Joinson, 2001). Adoption of the most suitable method of communication for collaborative interpretation tasks is important to design effective interaction systems. Some studies have focused on the effect of persuasive communication based on the type of media. In these studies, the difference in persuasiveness between text-based communication and oral communication has been the focus (Kiesler, Siegel, & McGuire, 1984). Text-based communication is more likely to change opinions than oral communication. This indicates that the effectiveness of social pressure may differ based on the method of communication.

An interesting survey conducted by Dennis & Williams (2003) shows that activities in electric brainstorming may facilitate creative activities as the number of members increase. It points out that, negative factors known as process-loss can be reduced in text-based interaction compared to oral based interaction. It is also hypothesized that text-based media may enhance the presence of the conversational agents and, thus, create greater social facilitation. The authors conducted experiments based on this line using multiple ECA in a chat-based interpretation task (Hayashi, in press). However, it was still unclear how the quality of the cognitive process may change under such environments. The present study will provide new evidence focusing the cognitive process throughout an interpretation task with an ECA.

1.2 Goal and hypothesis

The goal of this study was to investigate the factors that are useful to the design of embodied conversational agents to be used as peer collaborators. The present study investigates the efficient use of role-taking embodied conversational agents for facilitating creative cognition process during collaborative activities. Specifically, we focus on the influence of two factors that are related to the social psychological and human interface factors: the number of agents and the method of communication. The effects of the number of conversational agents (single vs. dual) and method of communication (voice vs. text) were investigated in an experimental design. The following shows the hypothesis of the present study.

H1: In a creativity task, an individual interacting with several agents will facilitate better cognitive process than a single agent.

H2: Such cognitive process may facilitate when communicating with text-based media compared with oral communication.

2. Method

The present study focuses on the interaction process pointed out in the creative model in Figure 1, and investigates how conformation bias can be eased and unique ideas can be generated with the use of embodied conversational agents. To capture the nature of cognitive process, a nonsensical figure called a doodle was used (Price, 1953). A doodle is a figure that is ambiguous and thus can be interpreted in many ways. Figure 2 shows the ten examples of doodles that were used as the stimuli in this experiment.

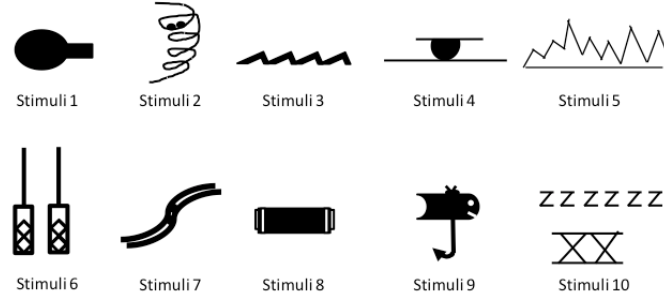


Figure 2. Examples of stimuli used in the study.

The task for the participants in the present study was to generate as many interpretations of the stimuli in limited time. For example, the fifth stimuli (stimuli 5) can be interpreted in many different ways, including mountains, radars, or lightning. Several types of stimuli were taken from the study by Price (1953) and reorganized. In the task, a doodle stimulus was presented to the participants and they were asked to generate as many different interpretations as possible in five minutes. In addition, a conversational agent joined this activity as a collaborating partner, and the participant was required to report his or her interpretations to the agent. The agent's role was to monitor the interpretations and provide suggestions about the generated idea. This part played the role for explore & revise the cognitive process shown in Figure 1. Suggestions were based on an evaluation of the uniqueness of each interpretation. The criteria for the determination of uniqueness was based on a database developed prior to the task (see the next section).

2.1 Doodle database

We conducted a pilot experiment to develop a classification system for the interpretations of the doodles on a unique to non-unique scale. The participants of this experiment, 120 undergraduate university students, were asked to interpret each of the ten stimuli for a free recall test. The experiment took place in a computer room, and students received a course credit. All participants entered their interpretations of the doodles on a web site by inputting their interpretations about the image. The data were collected and pooled for the use as the standard population for general interpretations of the stimuli. For the 10 stimuli in Figure 2, participants generated 244 different types of interpretations, for a total of 1763 interpretations. From each stimuli data set, we calculated the frequency of appearance for each interpretation type, to define its popularity. More specifically, interpretation type β for stimulus i was coded with the following labels:

- rare: $0\% = \beta_i$
- unique: $\beta_i \leq 30\%$,
- so-so: $31\% \leq \beta_i \leq 50\%$,
- major: $51\% \leq \beta_i$.

Interpretations that were labeled “major” were considered as easy, “so-so” were considered average, “unique” were considered difficult interpretations to generate, and “rare”

were considered as very creative. From the collected data, 8 out of 10 doodle stimuli, with good category distribution were used in this experiment.

2.2 System

Figure 3 shows the experimental setup. The system was composed of three sub-systems: (1) client interface, (2) server, (3) client agents, and (4) stimuli presenter. The experimental set up followed by the experiment conducted by Hayashi (in press) except with minor changes in parameters of the system.

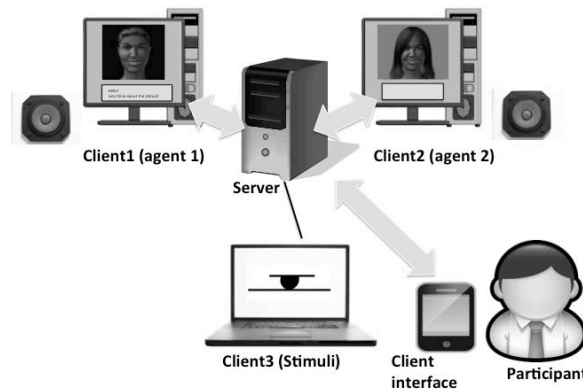


Figure 3. Example of experimental set-up.

The participant was asked to look at the stimuli and make as many interpretations as possible while receiving suggestions from the embodied conversational agents. Participants were told that the agents were collaborating partners and were making suggestions about the uniqueness of their interpretations. Participants used a tablet device (Android OS 4.0) as the communication interface with the computers. A computer server that generated the stimulus of the doodle pictures on a laptop computer was in front of the participant. There were one or two (depending on the experimental condition) client computers with embodied conversational agents presented on an 18.5-inch monitor next to the server. All the computers were connected through the local area network (LAN) using TCP/IP. Participants used buttons start the experiment and to change the stimulus presented, and the text field to input their interpretations of the stimulus. Users first clicked the start button and then clicked to view the first picture. Participants were also able to send their interpretations to the other computers by voice or text. Voice recognition API provided by Google was used in the voice option. The server was used for receiving messages from the participant, generating a stimulus, sending information to the agents, and recording the entire process. The stimulus was presented on the server through an application manipulated in Java. The stimulus was presented in the middle of the screen.

The server sent a message to individual clients that signaled them to communicate at the appropriate times. Each client received messages and used a computer-synthesized voice to make suggestions. The client computers had different types of agents installed. The characters that appeared were created using Poser 8 (www.e-frontier.com), which is a design tool for 3D images and animations. The agents' suggestions were generated on the basis of the encoded labels that were stored in the database described in the previous section. When the agent could not detect words from the database, the agent encoded the interpretation as "rare". A typical rule-based system, was used to generate the response by using the rules:

If "major "

-- > "This idea is a popular idea"

Elseif "so-so "

-- > "Well, this is a little popular response"

Elseif "unique "

-- > " The idea you say, "%input text%" is quite a nice idea."

Else“ rare ”

-- > “I have never seen such a idea.”

The responses from the agent shown above are examples of several response variations (8 statements) that were randomly selected for each trial. When two agents were present, they alternated making comments to the participant. The timing of sending messages was defined and controlled by the server. The expressions were changed such that they appeared to differ across agents, although meaning remained the same. The agents did not generate any interpretations and only played the role of a collaborative partner by providing evaluative feedback.

2.3 Experimental design and participants

The experiment followed a 2×2 between-subjects factorial design (See Table 1). The first factor was the number of the agents that provided suggestions. A single condition was defined as one agent responding, and when two agents responded, it was called a dual condition. The second factor was the method of communication. When text-based messages were used to send comments to the agent, it was called the text condition; when participants used voice messages, it was called voice condition. The participants were instructed to look at the image that was presented on the server, and interpret it. They were instructed to use the tablet device to send messages to the agent. They were told that the agent was a collaborating partner and would respond about the quality interpretation.

Table 1: Experimental conditions.

	single	dual
text	text/voice	text/dual
voice	voice/single	voice/dual

Eighteen undergraduate students participated in the experiment. All participants were assigned to one of the four conditions. Each participant completed all the trials, and the order was counter-balanced. For each condition, there were two trials of stimuli interpretation. Each trial lasted 5 minutes, and the total experiment time was approximately 40 minutes. The experiment took place in an acoustic room, and each participant was alone during the trial. The voice and text conversations of the participants were collected and analyzed. In order to evaluate the creative process, the following variables were calculated by using the evaluation system described in the previous section : (1) 'creative' (rare + unique: $0\% \leq \beta_i \leq 30\%$), and (2) 'general' (so-so + major: $31\% \leq \beta_i$).

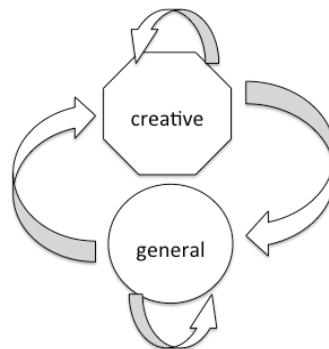


Figure 4. Transitions of the generated words.

The present study focuses on the interaction process of the quality of cognitive process. Therefore, the transitions of the process of the two types of words were analyzed. More specifically, the patterns of the transitions of the following were analyzed during each trial in each condition: (1) general to general, (2) creative to creative, (3) creative to general, and (4) general to creative (See Figure 4.).

3. Results and discussions

Figure 5 lists the average number of interpretations. The vertical axis represents the ratio of the number of generated ideas. Analysis of a 2×2 within-subjects factorial ANOVA with the agent number (one vs. two) and communication method (text vs. voice) as independent variables for each transition type. For the type of (1) general to general, there was no significant interaction between the two factors ($F(1, 68) = 1.312, p = .26$). However, simple main effects analysis showed that participants in the double-agent condition generated more ideas than did participants in the single-agent condition ($F(1, 68) = 4.593, p < .05$). Next, for (2) creative to creative, there was no significant interaction between the two factors ($F(1, 68) = 1.880, p = .17$). Also, for (3) creative to general, there was no significant interaction between the two factors ($F(1, 68) = 3.123, p = .08$). Finally, for (4) general to creative, there was significant interaction between the two factors ($F(1, 68) = 5.663, p < .05$). Next, an analysis of a simple main effect was conducted based on number factor and found that text based interaction was better than oral based interaction in the two agent situation ($F(1, 68) = 5.061, p < .05$). However there were no differences in other conditions ($F(1, 68) = 1.245, p = .27$; $F(1, 68) = 2.165, p = .15$; $F(1, 68) = 3.588, p = .06$).

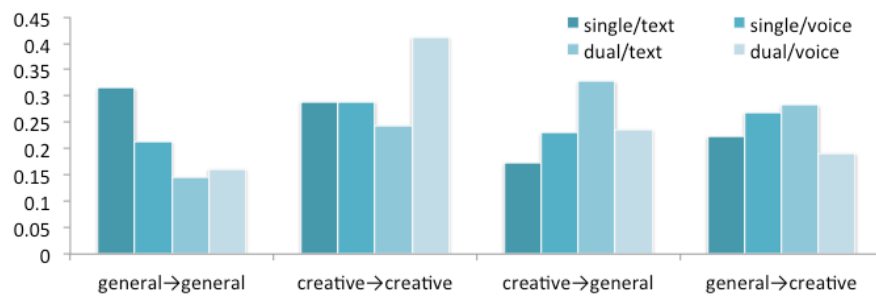


Figure 5. Results of the transitions.

The interaction on the (4) genera-creative show that the synergy created by the use of multiple agents along with a voice communication enhanced the cognitive process for the quality of creative interpretations. These results suggest that the number of agents and the method of communication are important factors in designing effective embodied conversational agents in creative activities. These results both support Hypothesis 1 & 2. This shows that when using ECA's as peer facilitators in a creative generation task, it is effective on facilitating the creative process when using multiple agents along with a text-based interface. These could be important factors on designing creativity supporting collaborating systems in the future.

4. Conclusions

The goal of the study was to investigate the efficient use of role-taking embodied conversational agents in the facilitation of creative cognition during collaborative activities. The study focused on the influence of two factors, the number of agents and method of communication, were related to the social psychological and human interface factors of the peer-partner agents and their human counterparts. These factors were investigated through an experimental design that varied the number of conversational agents (single vs. dual) and the method of communication (voice vs. text). We used a task where participants viewed a stimulus and interpreted it in as many different ways as possible while receiving suggestions from embodied conversational agents. Participants were told that the agents were collaborating partners, and were making suggestions about the quality of the interpretations. Results showed that the use of multiple agents with text-based interfaces facilitates the quality of creative interpretation process. These results suggest that the number of agents and the method of

interaction media is an important factor when designing ECA's as facilitators for enhancing idea generation and reinforcement process in creative cognition.

Acknowledgements

This work was supported, (in part) by 2012 KDDI Foundation Research Grant Program and the Grant-in-Aid for Scientific Research (KAKENHI), The Ministry of Education, Culture, Sports, Science and Technology, Japan (MEXTGrant), Grant No. 25870910

References

- Beck, B. U., Wintermantel, M. & Borg, A. (2005). Principles of regulating interaction in teams practicing face-to-face communication versus teams practicing computer-mediated communication," *Small Group Research*, 36, 499–536.
- Dennis, A. R., & Williams, M., L. (2003) Electric Brainstorming: Theory, Research, and Future Directions, P.B. Paulus and B. Nijstad, A, eds., no.160-178, *Group Creativity*, Oxford: University Press.
- Finke, R. A., Ward, T. B., & Smith, S. M. (1992). *Creative Cognition: Theory, Research, and Applications*. The MIT Press, MA: Cambridge.
- Hayashi, Y., & Ogawa, H. (2012 a). Facilitating creative interpretations on collaboration with multiple conversational agents, *Proceedings of the 10th Asia Pacific Conference on Computer Human Interaction (APCHI 2012)*, 443–449.
- Hayashi, Y. (2012 b). On pedagogical effects of learner-support agents in collaborative interaction. In S.A. Cerri & B. Clancey (Eds.): *Proceedings of the 11th International Conference on Intelligent Tutoring Systems (ITS 2012)*, Lecture Notes in Computer Science, 7315, 22–32.
- Hayashi, Y. (2013 a). Learner-Support Agents for Collaborative Interaction: A Study on Affect and Communication Channels, *Proceedings of the 10th International Conference on Computer Supported Collaborative Learning (CSCL 2013)*, 232–239.
- Hayashi, Y. (2013 b). Pedagogical conversational agents for supporting collaborative learning: Effects of communication channels, *Proceedings of the 31th International Conference on Computer Supported Collaborative Learning (CHI 2013)*, 655–660.
- Hayashi, Y. & Ono, K. (in press). Embodied Conversational Agents as Peer Collaborators: Effects of Multiplicity and Modality. *Proceedings of the 22nd IEEE International Symposium of Robot and Human Interactive Communication (Ro-Man 2013)*.
- Holmes, J. (2007). Designing agents to support learning by explaining. *Computers & Education*, 48(4), 523–547.
- Jhonsen-Laird, P. N., & Wason, P. C., (1977) *A theoretical analysis of insight into a resigning task, and post script*. In N. P. Jhonsen-Laird and C. P. Wason (Eds.), *Thinking: Readings in cognitive science* (pp. 143–157). Cambridge: Cambridge University Press.
- Joinson, N. A., (2001). Self-disclosure in computer-mediated communication: the role of self-awareness and visual anonymity, *Journal of Abnormal and Social Psychology*, 31(2), 177-192.
- Kiesler, S., Siegel, J., & McGuire, T. (1984). Social psychological aspects of computer-mediated communication," *American Psychologist*, 39, 1123–1134.
- Kim, Y., Baylor, A. L., & Shen, E. (2007). Pedagogical agents as learning companions: The impact of agent emotion and gender. *Journal of Computer Assisted Learning*, 23(3), 220–234.
- Lee, J. E., and Nass, C. (2002). Experimental tests of normative group influence and representation effects in computer-mediated communication when interacting via computers differs from interacting with computers," *Human Communication Research*, 28(3), 349-381.
- Levine, D., Resnick, B. L. & Higgins, T. E. (1993). Social foundations of cognition," *Annual Review of Psychology*, 44, 585-612.
- Miyake, N. (1986) Constructive interaction and the interactive process of understanding. *Cognitive Science*, 10(2), 151–177.
- Okada, T., & Simon, H. (1997). Collaborative discovery in a scientific domain. *Cognitive Science*, 21(2), 109–146.
- Price, R. (1953). *Doodles*, Simon & Schuster.
- Smith, S. M., Ward, T. B. & Schumacher, J. S. (1993). Constraining effects of examples in a creative generation task," *Memory & Cognition*, 21, 837–845.

Preliminary Assessment of Online Student-Generated Tests for Learning

Fu-Yun YU

^a*Institute of Education, National Cheng Kung University, Taiwan*

*fuyun.ncku@gmail.com

Abstract: When noting that constructing “tests” is different from constructing questions, its use for learning is yet to be explored. A study involving a total of 54 student teachers was conducted. An online student-generated tests system supporting associated tasks was adopted. Preliminary data on students’ perceptions with regard to its use as an assessment and learning approach, as compared to teacher-generated tests, were collected and analyzed. Several important findings were obtained. First, more than three-quarters of the participants preferred student-generated test as the approach for assessing their learning. Second, the majority of the participants thought student-generated tests promote better learning. Third, based on chi-square goodness of fit tests (X^2), students’ preference to and perceptions of student-generated tests and teacher-generated tests were statistically significant at $p < .01$. Finally, students’ written responses analyzed using the constant comparative method indicated that student-generated tests is a promising assessment and learning approach. Based on the collected data, suggestions for online system developments of similar kinds and instructional implementations are provided.

Keywords: online learning system, revealed preference, student-generated questions, subjective perceptions

1. Introduction

Enabling and empowering students to find out what they view as relevant and important when engaged in learning and to construct questions around those identified areas has attracted the attention of an increasing number of researchers and practitioners. This arrangement, known variably as student-generated questions, problem posing, student question-generation, and so on (hereafter name SQG), is a notable comprehension-fostering and -monitoring cognitive strategy.

The learning benefits of SQG on cognitive, affective and social development have been well-documented (Abramovich and Cho, 2006; Barlow and Cates, 2006; Brown and Walter, 2005; Chi, Brown and Bruce, 2002; Rosenshine, Meister and Chapman, 1996; Whitin and Whitin, 2004; Wong, 1985; Yu and Liu, 2005). To take advantage of the various affordances of networked technologies, currently more than a dozen online learning systems have been developed to support students constructing questions (Yu & Wu, 2012). As constructing “tests” would direct students’ attention to additional criteria (e.g., the distribution of course concepts to be learned) and is different from constructing questions (Chamoso and Ca’ceres, 2009), its use for learning serves as the focus of this study. In this study, students’ perceptions with regard to its use as an assessment and learning approach, as compared to teacher-generated tests, are examined to yield preliminary assessment data.

2. Preliminary Assessment of Online Student-Generated Tests for Learning

3.1 Participants

In light of the fact that constructing questions and tests are essential skills expected of teachers, student-generated questions and tests activities were carefully integrated into a course offered through a secondary teacher preparation program at a national university in Taiwan. A total of fifty-four student teachers enrolled in the course and participated.

3.2 Implementation procedures

In the first class, after the instructor introduced the general arrangement, requirements and course format, the purposes for incorporating SGQ and student-generated tests in this course were briefly explained. Considering that multiple-choice is the question type that dominates teacher certificate examination administered at the national level, and it is one of the most frequently encountered question types in exams at the secondary education level, it was chosen for this study. An online student-generated tests system supporting associated tasks was adopted. For description on the system, please refer to Yu and Su (2013).

The study was divided into two stages. At the first stage, as a routine practice, following instructor's delivery of instruction on each chapter, students were given twenty minutes to generate at least two multiple-choice questions pertaining to the covered content. Before engaging students in SQG, a training session covering the basic concepts related to SGQ and operational procedures for interaction with the adopted system was arranged to equip students with essential skills. After class, students were asked to assess at least four randomly assigned questions so that individual feedback from peers could be obtained, and SGQ could be revised with reference to peers' feedback when the question-author deemed appropriate. At the next class session, group feedback was given by a teaching assistant to highlight exemplary question-generation and -assessment practices.

At the second stage of this study, students were instructed to construct a test covering all the study content in this course, based on self-generated questions. As a learning support, students were also given a chance to provide feedback to peer-generated tests and observe peers' work during the process. A training session covering the basic concepts and operational procedures of associated tasks (e.g., test-construction, test-assessment, test-viewing) was given before engaging students in generating tests.

To collect preliminary data regarding students' perceptions toward student-generated test, participants were given a questionnaire at the last instructional session. Students' response to the following two questions were analyzed and reported in this study to yield preliminary assessment of its use for learning:

1. Which of the following do you prefer better as an approach for assessing your learning (student-generated tests, traditional teacher-generated tests, or no difference)? Why?
2. Which of the following do you think promote better learning (student-generated tests, traditional teacher-generated tests, or no difference)? Why?

3. Results and Conclusions

Quantitative data from question #1 indicated that more than three-quarters of the respondents (77.78%) preferred student-generated test as the approach for assessing their learning. Only nearly 10% (9.26%) preferred traditional teacher-generated test, and 12.96% expressed no preference to either approaches. A chi-square goodness of fit test (χ^2) further indicated that the distribution was statistically significant at $p < .01$ ($\chi^2 = 48.11$).

Students' written responses to Question #1 were analyzed using the constant comparative method proposed by Lincoln and Guba (1985). Several salient features emerged as to why student-generated tests were their preferred assessment and learning approach, and could be grouped into two categories: affective and cognitive effects. For affective effects, student-generated tests as being '*less stressful*', and '*novel, interesting and lively*' was mentioned by 16, and seven respondents, respectively. As for cognitive effects, its focus on '*application rather than rote memorization*,' and '*provision for exercising higher-order thinking skills*,' such as cognitive strategy (e.g., building linkage to personal life, other subjects, or future work; locating main ideas of the study content), metacognitive strategy (e.g.,

self-monitoring of comprehension; self-revision; integration of learned material), generative process, self-regulation, reflective thinking, and so on, was stressed by 24 and 12 respondents, respectively. Finally, five respondents highlighted the ‘*meaningfulness*’ of student-generated tests as it provided an opportunity for students to practice generating questions, which is an essential skill expected of teachers.

Quantitative data from question #2 showed that more than 60% of the respondents (61.11%) regarded student-generated tests promote better learning, while nearly 30% (29.63%) expressed no differences and nearly 10% (9.26%) considered traditional teacher-generated tests. A chi-square goodness of fit test (X^2) further indicated that the distribution was statistically significant at $p < .01$ ($X^2 = 22.11$). Students’ written responses to question #2 were also analyzed using the constant comparative method. Results reflected basically what were revealed in the previous paragraph. Generally speaking, students felt that the aforementioned processes and effects altogether helped engender a ‘*sense of achievement*,’ and ‘*higher interest associated with learning*,’ which in turn lead to ‘*better retention*,’ ‘*cognitive development*’ and learning.

In sum, preliminary assessment data from students’ responses supported student-generated tests as a promising assessment and learning tool. Developers of online student-generated questions learning systems are strongly suggested to consider the enhancement of their current systems to allow students to generate tests using student-generated questions as a basis. With such an enhancement in place, instructors can integrate student-generated tests following SGQ learning activities to further promote learning and cognitive growth.

Acknowledgements

This paper was funded by research grants from the National Science Council, Taiwan (Project: Online Student-Generated Tests Learning System: Development, Applicability and Learning Effects, NSC 102-2511-S-006-003-MY3). The author would like to thank Chiyu Yang, the teaching assistant of the course under which the evaluation study was conducted.

References

- Abramovich, S., and Cho, E.K. (2006). Technology as a medium for elementary preteachers’ problem-posing experience in Mathematics. *Journal of Computers in Mathematics and Science Teaching* 25 (4), 309-323.
- Barlow, A., & Cates, J.M. (2006). The impact of problem posing on elementary teachers’ beliefs about mathematics and mathematics teaching. *School Science and Mathematics*, 106(2), 64-73.
- Brown, S.I., & Walter, M.I. (2005). *The art of problem posing* (3rd ed.). New Jersey: Lawrence Erlbaum Associates.
- Chamoso, J. M., & Ca’ceres, M. J. (2009). Analysis of the reflections of student-teachers of mathematics when working with learning portfolios in Spanish university classrooms. *Teaching and Teacher Education*, 25(1), 198-206.
- Chin, C., Brown, D. E., & Bruce, B. C. (2002). Student-generated questions: A meaningful aspect of learning in science. *International Journal of Science Education*, 24, 521-549.
- Lincoln, Y. S. & Guba, E. G. (1985). *Naturalistic inquiry*. Beverly Hills, CA: Sage Publications.
- Rosenshine, B., Meister, C., & Chapman, S. (1996). Teaching students to generate questions: a review of the intervention studies. *Review of Educational Research* 66 (2), 181-221.
- Whitin, D. J. & Whitin, P. (2004). *New visions for linking literature and mathematics*. Urbana, IL: National Council of Teachers of English. Reston, VA: National Council of Teachers of Mathematics.
- Wong, B. Y. L. (1985). Self-questioning instructional research: A review. *Review of Educational Research*, 55, 227-268.
- Yu, F.Y., & Liu, Y.H. (2005). Potential values of incorporating multiple-choice question-construction for physics experimentation instruction. *International Journal of Science Education*, 27(11), 1319-1335.
- Yu, F. Y. & Su, C-L (2013/5/7). *The design, development and preliminary evaluation of an online student-generated tests learning system*. Accepted for presentation at ICCE2013, Bali, Indonesia, November 18-22, 2013.

Yu, F. Y. & Wu. C. P. (2012). Student question-generation: The learning processes involved and their relationships with students' perceived value. *Journal of Research in Education Sciences*, 57(4), 135-162.

Empirical Study on Errors of Mathematical Word Problems Posed by Learners

Kazuaki KOJIMA^{a*}, Kazuhisa MIWA^b & Tatsunori MATSUI^c

^a*Learning Technology Laboratory, Teikyo University, Japan*

^b*Graduate School of Information Science, Nagoya University, Japan*

^c*Faculty of Human Sciences, Waseda University, Japan*

*kojima@lt-lab.teikyo-u.ac.jp

Abstract: Problem posing by which learners create problems by themselves has been identified as an important activity in mathematics education. However, problem posing is a heavy task for both learners and teachers because it is a divergent task that has various possible answers. To develop problem posing skill of learners, it is indispensable to evaluate posed problems, particularly when they include errors in mathematical structures. To provide a basis in designing computational support for addressing errors to improve problem posing skill, this study empirically investigated errors of mathematical word problems posed by novices. Undergraduates were engaged in a problem-posing task where they were asked to pose many, diverse and unique problems from a problem initially given. Posed problems that included errors were analyzed, with the result indicating that when the undergraduates failed to pose problems, their problems mostly had errors regarding setting constraints. We then discussed how to approach errors in problem posing by computational systems.

Keywords: Problem posing, mathematical learning, word problems, computational support

1. Introduction

In addition to solving problems given by a teacher or textbook, problem posing, by which learners create problems by themselves, has also been identified as an important activity in mathematics education. In fact, some mathematicians and mathematics educators have pointed out that problem posing lies at the heart of mathematical activity (e.g., Polya, 1945; Silver, 1994). Problem posing is necessary skill in problem solving of everyday life. Because structured problems are not provided when using mathematics in everyday life, problem solvers must recognize and formulate problems by themselves (Singer, & Voica, 2013). Nevertheless, learning of problem posing is hardly adopted in school classrooms. One of the reasons for this may be that problem posing imposes high loads on both learners and teachers. Problem posing is a divergent task that requires novel idea generation from learners. Therefore, it is a heavier task for learners than problem solving. It is also heavy for a teacher. Because problem posing does not have a unique answer but various possible answers, a teacher must evaluate each of problems posed by learners and respectively provide feedback. To develop problem-posing skill feasible in everyday life, it is indispensable to individually evaluate posed problems particularly when they include errors in mathematical structures. Novice learners have difficulty in composing structures of problems, and they can fail in it (Kojima, Miwa, & Matsui, 2010a; 2011b). Therefore, incorrect problems including errors must be addressed to improve learner skill. However, it is in general a difficult task to evaluate incorrect responses in a divergent task.

Several studies have addressed evaluations of posed problems by developing computational support systems. Some of them adopted peer evaluations among learners (e.g., Barak, Rafaeli, 2004; Takagi, Teshigawara, 2006; Hirai, Hazeyama, & Inoue, 2009; Yu, Liu, & Chan, 2005). They basically use multiple-choice format problems that question declarative knowledge. They have not adapted to domains of problems that have structural features, such as mathematics. Hirashima and his colleagues implemented learning environments for learning by problem posing in arithmetic word problems and physics problems (Hirashima, Yokoyama, Okamoto, & Takeuchi, 2007; Yamamoto, Waki, & Hirashima, 2010). Learners pose problems by combining cards of sentences or physical objects initially provided in these environments. Because the range of problems possible to pose is limited in the

environments, they can automatically evaluate posed problems and provide feedback for errors. However, these studies focus on improving learner understanding of domain knowledge or problem-solving skill through problem posing. There have not been sufficient studies regarding support for improving problem-posing skill in terms of errors.

To provide a basis in designing computational support for educating problem-posing skill, this study empirically investigated errors of mathematical word problems posed by novices. Although it has been reported that novices can pose unsolvable or incorrect problems (Kojima et al., 2010a; 2011b; Leung, & Silver, 1997), precise analysis of such problems has not been performed. We analyzed problems from data empirically obtained in our previous studies (Kojima, Miwa, & Matsui, 2010a; 2010b; 2011a), which includes errors (e.g., inconsistency between problem texts and solutions, or mathematically incorrect relationships). We then discussed how to approach errors in problem posing by computational systems.

2. Method

2.1 Experimental Procedures

We collected problems posed by general undergraduates of a wide range of background (e.g., psychology, computer science or welfare) in four cognitive science classes held in from 2009 to 2012. The topic of the classes was creativity. The undergraduates were engaged in a problem-posing task where they were asked to pose from a problem initially given and to write their texts and solutions on provided sheets in 20 minutes. The initial problem was the following word problem solved with a unitary equation (a single linear equation/contradictory), which is used in middle school mathematics education.

I want to buy a certain number of boxes of cookies. If I buy some 110 yen boxes of cookies, then I have 50 yen left. If I buy some 120 yen boxes of chocolate cookies, then I need 20 yen more. How many boxes do I want?

Solution.

Let x denote the number of boxes.

$$110x + 50 = 120x - 20$$

According to the equation above, $x = 7$.

The undergraduates were asked to pose as many and different problems as possible. They were encouraged to pose diverse problems different from the initial problem, and unique problems different from those posed by the other undergraduates. They were also instructed that their problems should be solved with unitary equations and middle school students should be able to solve it.

In three of the four classes, undergraduates learned a problem as an example of output of problem posing in the domain of word problems solved with simultaneous equations before start of the task. In the class at 2010, undergraduates learned the example by solving it. In 2011, undergraduates reproduced the same problem as the example. In 2012, undergraduates evaluated the example in terms of the originality and usefulness. The purpose of the previous studies in 2010, 2011 and 2012 was to examine whether learning of the example had impact on the problem-posing task. However, we do not discuss this point because the purpose of this study is to examine errors that novices make in the problem-posing task.

2.2 Data and Analysis

Some of problems posed by the undergraduates included errors. These error problems were excluded from analysis in the previous studies because they had no answers, had answers that were arbitrary values, or had solutions that were inconsistent with their texts.

We classified the errors into the following categories according to their matters, expanding classifications by Leung and Silver (1997).

- *No mathematical relationships*: Problems of this category had texts that included numeric parameters, but they included no mathematical relationships among the parameters.

- *Inappropriate relationships*: This category had problem texts that embedded relationships among numeric parameters, but they were mathematically inappropriate.
- *Inconsistent solutions*: This category had problem texts that had mathematically appropriate relationships, but solutions that undergraduate described were not consistent with the relationships in the texts.
- *Contradictory constraints*: This category had no answers because constraints in problem texts were contradictory.
- *Insufficient constraints*: This category had answers of arbitral values because problem texts did not provide constraints enough to lead unique answers.
- *Excessive constraints*: This category had problem texts that had mathematically appropriate relationships, but the problems can be solved without formulating equations from the relationships because of excessive information.

3. Results

Five hundred and forty seven undergraduates participated in the problem-posing task in the four classes. They posed 854 problems. Eighty two of the posed problems were not in the domain of word problems solved with unitary equations. Forty two of the other 772 problems included errors. Examples of error problems in each category are as follows.

- *No mathematical relationships*

On a school trip, teachers distributed lunch boxes of beef or chicken to students. Ten teachers distributed lunch boxes of beef and 5 teachers distributed lunch boxes of chicken. Three students were waiting to receive beef, and 2 students were waiting to receive waiting to chicken. How many students were there?

The solution of this problem was not described. This problem includes no mathematical relationships that can find the number of students.

- *Inappropriate relationships*

An express train is 4 times faster than a local train. Today, the train service was delayed due to an accident. An express train arrived at the terminal station 40 minutes later than usual, and a local train arrived at the terminal station 10 minutes later than usual. Find minutes it usually takes for an express train to arrive at the terminal station. The delay time of an express train was the same as that of a local train.

Solution.

Let x denote minutes to arrive the terminal station.

$$x + 40 = 4x + 10$$

According to the equation above, $x = 10$.

This problem does not pose appropriate information to formulate the solution described. It should pose a setting such as “a local train leaving in 10 minutes and an express train leaving in 40 minutes will arrive at the terminal station at the same time.”

- *Illegal constraints*

I want to buy a certain number of writing materials. The amount of 3 pencils and a 120 yen notebook is equal to the amount of a red pencil and the same notebook. A red pencil is 20 yen more expensive than 3 pencils. How much a pencil is?

Solution.

$$3x + 120 = (3x + 20) + 120$$

According to the equation above, $x = 40$.

This problem has no answer because the right and left sides of the equation are not equal. A notebook whose price is different should be bought with a red pencil.

- *Inconsistent solutions*

A teacher is planning to divide students into a certain number of groups. If 3 students are assigned to each group, then 2 students are left. If 4 students are assigned to each group, then 1 student is left. How many students are there?

Solution.

Let x denote the number of students.

$$x / 3 + 2 = x / 4 + 1$$

According to the equation above, $x = 17$.

Although x is not 17 but -12 in this equation, that is not the critical matter. The solution described is not correct. The correct solution of this problem is “ $(x - 2) / 3 = (x - 1) / 4$ ” and the answer is 5.

- *Insufficient constraints*

I want to buy a certain number of boxes of cookies. If I buy x 180 yen boxes of cookies, then I have 100 yen left. If I buy $x+1$ 180 yen boxes of cookies, I need 80 yen more. Find the value of x .

Solution.

$$180x + 100 = 180(x + 1) - 80$$

According to the equation above, $x = 5$.

This equation is changed to “ $0 = 0$.” The answer of this problem is any natural number. Information for the left and right sides of the equation should be different.

● *Excessive constraints*

I am in a book store and I have 900 yen now. If I buy 2 books, then I have 100 yen left. If I buy 3 books, then I need 300 yen more. How much does the book cost?

Solution.

$$2x + 100 = 3x - 300$$

$$x = 400.$$

This problem can be solved with “ $(900 - 100) / 2$ ” or “ $(900 + 300) / 3$ ” without formulating the equation. The parameter “900 yen” should be removed.

Figure 1 indicates the proportions of error problems in each category. About 75 % of the errors were due to matters in setting constraints posed in problem texts (contradictory constraints, insufficient constraints or excessive constraints).

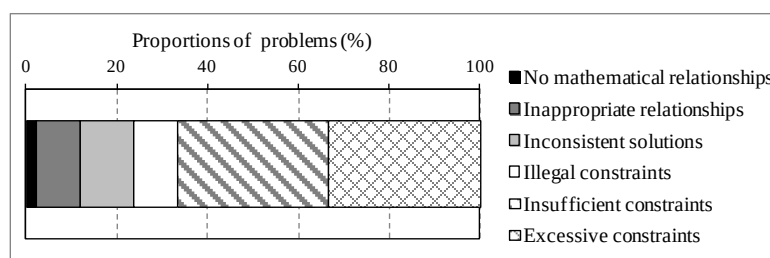


Figure 1. Proportions of error problems in each category

4. Discussion

The result shown in the previous section revealed that when the undergraduates failed to pose problems, their problems mostly had errors regarding setting constraints. They also indicated that the undergraduates did not necessarily find they made errors. Most of the error problems described their solutions and answers as shown in the examples above, even though the solutions were incorrect.

The undergraduates did not pose difficult problems, but rather posed simple problems. The initial problem given in the problem posing task is an elementary problem used in middle school mathematics education, which must be quite easy for undergraduates. In 730 posed problems other than the 42 error problems, 359 (49.2 %) had the same solution structure to the initial problem. The other 371 problems (50.8 %) had different solution structures. In terms of the complexity of solution structures (the numbers of mathematical operations needed in solving problems), 170 (23.3 %) of the 371 problems of different structures were more complex than the initial problems. Therefore, 76.7 % of the 730 posed problems were as simple as the initial problems, or simpler than it. Most of the error problems were also simple. As the example of excessive constraints, some of them were supposed to have the same solution structure to the initial problem. Although the number of the error problems was few, the undergraduates posed simple problems in the domain whose target learners are middle school students. If middle school students pose problems in the domain, they would pose more error problems. Accordingly, education of problem-posing skill must generally need support for detecting or correcting errors because many errors are expected.

In the cases of contradictory constraints or insufficient constraints shown above, errors can be detected by solving equations in solutions. It may be possible to prevent excessive constraints by bringing attention to a numeric parameter in a problem text when the parameter does not appear in it solution. However, it is indispensable to analyze problem texts in terms of semantic structures in order to accurately check errors or individually provide feedback. Such analysis is impossible for current computational systems due to technical limitations of natural language processing. Therefore, support by computational systems should aid novice learners in checking and correcting their problems by

themselves. One approach to aid check by learners is to present them with an example of an error problem and have them verify whether their problems include the same error. Learning of errors in problem posing may enable learners to improve their problem-posing skill. Thus, we are planning to examine the effect of verifying an error example by learners and implement a system that supports verification of error examples in the future work. When an error problem of contradictory, insufficient or excessive constraints is posed, a computational system can present an example similar to the problem by detecting its error type and parsing a structure of its equation. Such a similar example is considered to be useful for a learner in finding and correcting an error of his/her problem. However, we have to devise a new method to provide appropriate examples when problems of the other errors are posed.

Acknowledgements

This study was partially supported by the Grant-in-Aid for Young Scientists (B) 23700990 and 25870820 of the Ministry of Education, Culture, Sports, Science and Technology, Japan.

References

- Barak, M., & Rafaeli, S. (2004). On-line Question-Posing and Peer-Assessment as Means for Web-Based Knowledge Sharing in Learning. *International Journal of Human-Computer Studies*, 61(1), 84-103.
- English, L. D. (1997). Promoting a Problem-Posing Classroom. *Teaching Children Mathematics*, 4(3), 172-179.
- Hirai, Y., Hazeyama, A., & Inoue, T. (2009). Assessment of Learning in Concerto III: A Collaborative Learning Support System Based on Question-posing, In V. Uskov (Ed.) *Proceedings of CATE2009* (pp. 36-43). Calgary, Canada: ACTA Press.
- Hirashima, T., Yokoyama, T., Okamoto, M., & Takeuchi, A. (2007). Learning by Problem-Posing as Sentence-Integration and Experimental Use. In R. Luckin, K. R. Koedinger, & J. Greer (Eds.) *Proceedings of AIED2007* (pp. 254-261). Amsterdam, Netherlands: IOS Press.
- Kojima, K., Miwa, K., & Matsui, T. (2010a). An Experimental Study on Support for Learning of Problem Posing as a Production Task. *Transactions of Japanese Society for Information and Systems in Education*, 27(4), 302-315. (In Japanese)
- Kojima, K., Miwa, K., & Matsui, T. (2010b). Experimental Study on Methods of Learning from Examples and their Effects in Problem Posing. In *the 59th Meeting of the SIG on ALST of Japanese Society for Artificial Intelligence* (pp. 49-54). (In Japanese)
- Kojima, K., Miwa, K., & Matsui, T. (2011a). Study on the Effects of Learning Examples through Production in Problem Posing. In F. Yu, T. Hirashima, T. Supnithi, & G. Biswas (Eds.) *Proceedings of ICCE2011* (pp. 86-90). Pathum Thani, Thailand: National Electronics and Computer Technology Center.
- Kojima, K., Miwa, K., & Matsui, T. (2011b). Experimental Study on Failures in Composing Solution Structures in Mathematical Problem Posing. In A. F. M. Ayub, B. Cheng, K. Leelawong, F. Yu, T. Hirashima, & G. Biswas (Eds.) *Workshop Proceedings: Supplementary Proceedings of ICCE 2011* (pp. 370-377). Pathum Thani, Thailand: National Electronics and Computer Technology Center.
- Leung, S. S., & Silver, E. A. (1997). The Role of Task Format, Mathematics Knowledge, and Creative Thinking on the Arithmetic Problem Posing of Prospective Elementary School Teachers. *Mathematics Education Research Journal*, 9(1), 5-24.
- Polya, G. (1945). *How to Solve it*. Princeton, NJ: Princeton University Press.
- Silver, E. A. (1994). On Mathematical Problem Posing. *For the Learning of Mathematics*, 14(1), 19-28.
- Singer, F. M., & Voica, C. (2013) A Problem-Solving Conceptual Framework and its Implications in Designing Problem-Posing Tasks. *Educational Studies in Mathematics*, 83(1), 9-26
- Takagi, M., & Teshigawara, Y. (2006). A WBT System Enabling to Create New or Similar Quizzes Collaboratively by Students. In J. R. Parker (Ed.) *Proceedings of ICET2006* (pp. 263-268). Calgary, Canada: ACTA Press.
- Yamamoto, S., Waki, H., & Hirashima T.: (2010) An Interactive Environment for Learning by Problem-Changing. In S. L. Wong, S. C. Kong & F. Yu (Eds.) *Proceedings of ICCE 2010* (pp.1-8). Selangor, Malaysia: Universiti Putra Malaysia.
- Yu, F., Liu, Y., & Chan. T. (2005). A Web-based Learning System for Question-Posing and Peer Assessment. *Innovations in Education and Teaching International*, 42(4), 337-348.

The Design Principles of the Worked Examples

Chun-Ping WU^{a*} & Pi-Han LO^b

^a*Department of Educational Technology, TamKang University, Taiwan*

^b*Department of Educational Technology, TamKang University, Taiwan*

*cpwu303@gmail.com

Abstract: Problem-based learning strategy has been frequently adopted to develop students' problem-solving ability. Despite the fact that its effects have been reasonably argued and empirically tested, its associated learning task may overload the learners, especially the novice. This paper, grounded on the cognitive load theory, argued the potentials of introducing the worked examples into problem-based learning activity. The purpose of this study is to explore the design principles of worked examples and test its effects. The geometric logic problem type was chosen as the main problem for participants to explore during the problem-based learning activity. A series of geometric logic problems was developed and tested in a pilot study to ensure its quality. Furthermore, worked examples and practice session were developed based on the principles suggested in the literature. A web-based learning system was created to engage participants in observing the logical problems, watching the examples and practicing solving the given problems. A pre-and-post experimental design was adopted to test the effect of worked-examples. Twenty-eight university students, matriculated in information-related programs, were recruited. The finding supported the positive effect of the worked examples on enhancing students' logic problem solving performance.

Keywords: Geometric logic problem-solving, worked examples, problem-based learning

1. Introduction

Problem-based learning strategy has been extensively employed in many domains to enhance students' learning, thinking and problem-solving skills (Barrows, 1997; Gallagher, Sher, Stepien and Workman, 1995; Tiwari, Lai, So and Yuen, 2006). Problem-based learning starts learning with a real-world problem (Hmelo and Evensen, 2000) and encourages students' active exploration of the given problems and knowledge construction. During the process, students practice synthesizing learned concepts, constructing their schema as well as the problem-solving process. This process is cognitively demanding, which requires students to devote cognitive efforts to interpreting the problems, identifying domain knowledge that is relevant to the problems, generating, testing and evaluating possible solutions. The novice with less domain knowledge or problem-solving experience may be overloaded. Therefore, timely guidance provided to them may help them sustain their constantly cognitive engagement.

Prior studies have suggested incorporation of worked examples as a guidance into problem-based learning (e.g. Ayres and Paas, 2009; Kirschner, Paas, Kirschner and Janssen, 2010; Renkl, 1997; Sweller, van Merriënboer and Paas, 1998; van Merriënboer and Sweller, 2005). Providing worked examples can make it easier for students to associate the domain knowledge with the problem-solving process and grasp the problem solving skill as well. Therefore, this study explored the design principles of the worked example and tested the effect of worked examples on university students' problem-solving performance under the problem-based learning context.

2. Literature Review

2.1 Theoretical Foundation: Cognitive Load Theory

Cognitive load theory suggests that learning tasks impose cognitive loads on students. If the cognitive efforts demanded by a task exceed learners' cognitive capacity, meaningful learning will not occur (Sweller, 2010; Sweller et al., 1998). The cognitive load imposed by a learning task is determined by the complexity of the learning task and students' cognitive capabilities and knowledge. Specifically, the complexity of a task is estimated as the amounts of information elements presented and the complexity of the knowledge structure in which those information elements are embedded (Sweller, 2010). In order to correctly interpret and process a learning task, learners not only need to understand the concepts represented in the information elements, but also need to think through the interrelationships among those elements. Meanwhile, learners' cognitive capability and domain knowledge determine whether they could effectively and efficiently execute relevant schema to interpret and process the facing task.

The problem-based learning task itself might demand students' intrinsic cognitive efforts to explore the knowledge elements embedded in the given problem and task. However, students with less knowledge or lower cognitive capabilities might devote their attentions and efforts both to relevant and irrelevant information, which might exceed their limited cognitive capacity and thus, diminish the positive learning effect of problem-based learning (Sweller, 2010; Sweller et al., 1998). Therefore, it is essential to design appropriate worked examples not only to reduce the extraneous cognitive load imposed by problem-based learning, but also to engage students in making use of problem-based learning to manage their limited cognitive capacity to construct their schema (Ayres and Paas, 2009; Kirschner et al., 2010; Paas and van Gog, 2006).

2.2 Worked Examples

As suggested by cognitive load theorists, a well-design worked example could direct students' attention to relevant information and necessary reasoning process, decreasing cognitive efforts being devoted to reading the irrelevant information and trying-out the strategies (Renkl, Mandl and Gruber, 1996). Furthermore, it helps them to concentrate on schema activation, observing the problem-solving strategies and process presented in the examples, thus leading to construction of their own schema for solving similar problems (Atkinson, Derry, Renkl and Wortham, 2000; Paas and van Merriënboer, 1994; van Gog, Paas and van Merriënboer, 2004).

The essential components of the worked examples were summarized from the literature and discussed in a number of publications (Baghaei, Mitrovic and Irwin, 2007; Hmelo and Evensen, 2000; Moreno, 2006; Renkl, 1997; van Gog, Paas and van Merriënboer, 2006). First, the example should contain the problem representation, identifying the information that is critical for problem analysis. Second, the example should demonstrate experts' reasoning process and plan with explicit explanation of critical reasoning points. Third, the example should present the problem solving steps by explaining the concepts or strategies utilized and the rationale. Fourth, the example should stimulate students in thinking of causal effects and underlying principles. Fifth, students should be able to monitor their learning during interacting with the examples. That is, they could determine the amount of examples to observe and their learning pace. Last, students should be given the opportunity to practice problem-solving strategies learned from the examples.

3. Research Method

3.1 Research Design

Twenty eight university students majoring in information-related programs were recruited for the pre-and post-test experimental study. The geometric logic problem type was chosen as the main problem for participants to explore during the PBL activities. A series of geometric logic problems was developed and tested in a pilot study to ensure its quality. Furthermore, a series of worked examples and practice session were embedded in the web-based learning system, named Collaborative Exemplified Problem Reasoning System (CEPRS). The system allowed participants not only to interact with the given logic problems by watching the problem scenarios, trying out solutions, gaining instant feedback, but also to watch the worked examples. Furthermore, participants' solution paths and steps and time spent on watching each worked example and practice were recorded.

A training session was delivered at the beginning to ensure that the participants possessed the fundamental computer skills required for interacting with the given logic problems within the adopted learning system. After training, each participant accomplished the pre-test. Participants then worked with the system to conduct the learning task, which includes 5 example sessions and 5 practice sessions. The participants could watch the examples on their own pace before proceeding to practice applying the learned strategies to solve the logic problems. At the end, each participant accomplished the post-test.

3.2 Variables and Instruments

Five worked examples were designed and presented. First, in regard with the components of the examples, the first example focused on representing the problems by revealing important information and explaining how such information might influence ways to approach the problems. The rest of the four examples represented problems with different level of difficulty as well as introduced a strategy to guide students to reason through the problem and generate possible solutions. Second, all the examples demonstrated how the introduced strategy was utilized. Participants could observe each step of how a problem is solved and informed of the rationale for taking the step. Third, a practice session was presented after an example was demonstrated. The practice session, containing two problems with equivalent difficulty as those presented in the example. The practice session allowed participants to apply the learned strategy. Instant feedback was also provided to the participants so that they are able to monitor their own problem-solving process. Fourth, participants were granted the freedom to determine their learning pace. On one hand, they could use the control panel in the system to control their process of watching individual examples. On the other hand, they could determine the timing to switch between the example sessions and the practice sessions.

The dependent variable, which refers to students' logic problem-solving performance, was assessed by the correctness of solving the given 10 logic problems within 25 minutes. Both of the pre-test and posttest included 10 logic problems. To avoid the effects of practicing the test items, a parallel test was created. That is, the problem scenarios, goals, requirement and limitation adopted in the post-test are different from those adopted in the pre-test. Furthermore, a pilot test, recruiting 30 subjects, was conducted prior the actual study to ensure the quality of the tests. The difficulty of the items reported in the pilot study ranged from 0.36 to 0.86 and the averaged discriminability was 0.69, which indicated an acceptable quality of the instrument. The average difficulty and discriminability reported in the actual study was 0.45 and 0.55, respectively.

4. Results and Conclusions

The descriptive statistics of the variables are listed in Table 1. It can be seen that the post-test score (Mean=4.43) is higher than the pre-test score (Mean =7.71).

Table 1. Descriptive statistics

Variable	No.	Pre-test		Post-test	
		Mean	SD	Mean	SD
Worked Examples	28	4.43	2.13	7.71	1.82

The paired t-test result showed that the post test scores of the students working in the group of watching examples followed by practice were significantly higher than the pretest scores. ($t = 8.87, p < .01$). In other words, the participants' logic problem performance was significantly enhanced after being engaged in watching the worked examples.

This study contributed to the literature on problem-based learning. First, this study explored the design principles from the cognitive load theory perspectives and developed a series of the worked examples based on the principles. Second, this study validated the effect of the worked examples on enhancing students' logical problem-solving performance. As this study adopted the quantitative approach, experimental design, to investigate the effect of the worked examples on participants' growth in problem-solving performance, future research is suggested to take a qualitative approach to explore how subjects interact with the given worked examples to influence their subsequent problem-solving

activities. Furthermore, the geometric logic problem-solving was adopted as the core problem type in this study. Different problem types have different characteristics in problems representation and engage students in employing different problem reasoning and solving strategies. Therefore, to extend the design principles into developing worked examples for different problem types and empirically validate the effects would be important and highly recommended.

Acknowledgements

This paper was funded by the research grant from the National Science Council, Taiwan, ROC (NSC 101-2511-S-032-006). The author would like to thank research assistants, Zi-Xuan Su, Hung-Lun Kao, Jie-Wen Zheng, Hao jie Yong for their assistance during the learning system design and data collection process.

References

- Atkinson, R. K., Derry, S. J., Renkl, A., & Wortham, D. W. (2000). Learning from examples: Instructional principles from the worked examples research. *Review of Educational Research*, 70, 181–214
- Ayres, P., & Paas, F. (2009). Interdisciplinary perspectives inspiring a new generation of cognitive load research. *Educational Psychology Review*, 21, 1-9.
- Baghaei, N., Mitrovic, T., & Irwin, W. (2007). Supporting collaborative learning and problem solving in a constraint-based CSCL environment for UML class diagrams. *International Journal of Computer-Supported Collaborative Learning*, 2(2–3), 159–190.
- Barrows, H. S. (1997). Problem-based learning is more than just learning based round problems. *The Problem Log*, 2(2), 4–5.
- Gallagher, S. A., Sher, B. T., Stepien, W. J., & Workman, D. (1995). Implementing problem-based learning in science classrooms. *School Science and Mathematics*, 95(3), 136–146.
- Hmelo, C. E., & Evensen, D. H. (2000). Introduction. Problem-based learning: Gaining insights on learning interactions through multiple methods of inquiry. In D. H. Evensen & C. E. Hmelo (Eds.), *Problem-based learning: A research perspective on learning interactions*. Mahwah: Lawrence Erlbaum Associates Publishers.
- Kirschner, F., Paas, F., Kirschner, P. A., & Janssen, J. (2010). Differential effects of problem-solving demands on individual and collaborative learning outcomes. *Learning and Instruction*, 21, p587-599.
- Moreno, R. (2006). When worked examples don't work: Is cognitive load theory at an impasse? *Learning and Instruction*, 16, 170-181.
- Paas, F. (1992). Training strategies for attaining transfer of problem-solving skill in statistics: A cognitive load approach. *Journal of Educational Psychology*, 84, 429–434.
- Paas, F., & van Gog, T. (2006). Optimising worked example instruction: different ways to increase germane cognitive load. *Learning and Instruction*, 16, 87-91.
- Paas, F., & Van Merriënboer, J. J. G. (1994). Variability of worked examples and transfer of geometrical problem-solving skills: A cognitive-load approach. *Journal of Educational Psychology*, 86, 122–133.
- Renkl, A. (1997). Learning from worked examples: A study on individual differences. *Cognitive Science*, 21, 1–29.
- Renkl, A. (2005). The worked-example principle in multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 229–246). Cambridge, UK: Cambridge University Press.
- Renkl, A., Mandl, H., & Gruber, H. (1996). Inert knowledge: Analyses and remedies. *Educational Psychologist*, 31, 115–121.
- Sweller, J. (2010). Element interactivity and intrinsic, extraneous and germane cognitive load. *Educational Psychology Review*, 22, 123–138.
- Sweller, J., van Merriënboer, J. J. G., & Paas, F. G. (1998). Cognitive architecture and instructional design. *Educational Psychology Review*, 10, 251–296.
- Tiwari, A., Lai, P., So, M., & Yuen, K. (2006). A comparison of the effects of problem-based learning and lecturing on the development of students' critical thinking. *Medical Education*, 40(6), 547–554.
- van Gog, T., Paas, F., & van Merriënboer, J. J. G. (2004). Process-oriented worked examples: Improving transfer performance through enhanced understanding. *Instructional Science*, 32, 83–98.
- van Gog, T., Paas, F., & van Merriënboer, J. J. G. (2006). Effects of process-oriented worked examples on troubleshooting transfer performance. *Learning and Instruction*, 16, 154–164.
- van Merriënboer, J. J. G., & Sweller, J. (2005). Cognitive load theory and complex learning: recent developments and future directions. *Educational Psychology Review*, 17, 147-177.

Design of Tennis Training with Shot-timing Feedback based on Trajectory Prediction of Ball

Naka GOTODA^{a*}, Kenji MATSUURA^b, Koji NAKAGAWA^a & Chikara MIYAJI^a

^a*Japan Institute of Sports Science, Japan*

^b*The University of Tokushima, Japan*

*naka.gotoda@jpnnsport.go.jp

Abstract: Tennis has long history as a famous sport and enhanced health promotion of men and women all ages. In many cases, the style of technical teaching has been a long tradition of face-to-face. On another front, recent seamless bio-feedback technologies enable players to be trained in the acquisition of novice skills without the coach. This paper proposes a design and scenario of practice on their own with training system for tennis skills. One of the basic skills for the novices is to make an appropriate contact with the ball. We focus on skill related to judgment of shot-timing. The system provides the timing feedback based on trajectory prediction of ball. Image-processing module with Open CV preliminarily develops the estimated expression for the ball position by analyzing captured video frames. After that, the system gives color change to the ball according to the position with video projection. Therefore, a player can learn the appropriate shot timing easily. We will evaluate the training efficiency among comparison of practice using system with only one without system from the viewpoint of timing accuracy.

Keywords: Physical education, interactive learning, tennis, bio-feedback system, video projection

1. Introduction

Tennis has much player numbers all over the world. Similarly, in our nation, tennis including soft tennis has been always famous club sport among middle-school and high-school students. Therefore tennis is employed as physical education in a part of some school lessons in addition to lifelong sport among senior for health promotion. Under this background some novice people play tennis for the sheer fun of it, other novice people tackle to technical lesson from the spontaneous motivation of skill upgrade. The traditional way of technical teaching is face-to-face lesson. However, all novices cannot take lessons because a few coaches (e.g. physical education teacher) must limit the number of them for the purpose of keeping a certain level of teaching quality. Thus, when the lesson has many players compared with coaches, practices on their own hold a majority in the training activities.

On the other hand, integrated hardware and enhanced software technologies bring both tiny and high-speed sensing and audio-visual functions in several devices. For example, Eureka Computer Co., Ltd (2010) is calling for “e-Sports Ground” as an entirely-new field of sports entertainment with AR (Augmented Reality) technology with such seamless bio-feedback by using motion-sensor data and video projection. In particular, projector and video camera are distributed at low cost, many school are generally equipped with them. Therefore, combination with them has potential to provide players for a training method without the coach at school and so on.

Thus, we propose a design and scenario of practice on their own with training system for tennis skills. One of the basic skills for the novices is to make an appropriate contact with the ball. We focus on skill related to judgment of shot timing. For example of serve, the timing corresponds to appropriate height of the ball. The system provides the timing feedback based on trajectory prediction of ball. Image-processing module with Open CV preliminarily develops the estimated expression for the ball position by analyzing captured video frames. After that, the system gives color change to the ball according to the position with video projection. Therefore, a player can learn the appropriate shot timing easily. We will evaluate the training efficiency among comparison of practice using system with only one without system from the viewpoint of timing accuracy.

2. Related Research

2.1 *The Way of Motor-skill Development*

On the basis of Bersteine (1996) idea, it is required to acquire the fundamental skill knowledge about the fusions between how to evaluate several inputs and how to perform their body movements. He discussed such a motor dexterity and its development from the viewpoint of cognitive science and ecological psychology. In the field of such a motor development, following two theories take up initiative.

2.1.1 *Fitts & Posner's Three Stage Theory*

Fitts & Ponsner (1967) identified three stages of skill learning: “Cognitive”, “Associative”, and “Autonomous” stage. Learners can grow from unskilled performance with lots of errors to skillful performance with few errors. It means that they become more stable movement and better accuracy of timing through these steps. On the first step: “Cognitive” stage, a learner defines the goal of skill and recognizes a strategy of movement patterns which has several component parts for the achievement in her/his head. When a learner gets skill of tennis serve, the simple goal is shooting a static tennis ball in a comfortable position. In this case, a learner should pay attention to the following strategy as this stage during training:

- How to toss the ball in to the air?
 - How high?
 - Which direction?
- How to contact the ball with the racket?
 - Which timing?

Therefore, this stage is High degree of cognitive activity. On the next step: “Associative” stage, a learner links the parts like the abovementioned items into a smooth movement. This stage involves repeated practice by using feedback for the purpose of obtaining unchangeable reaction. Finally, on the last step: “Autonomous” stage, a learner can perform without conscious for the items. Of course, not all learners will reach this stage.

2.1.2 *Gentile's Two Stage Theory*

On the other hand, Gentile (1972) proposed two stages skill learning:

- Getting the idea of the movement
- Fixation / Diversification

This idea resembles Fitts & Posner's theory because the former stage corresponds to “Cognitive” stage and the other deals with both “Associative” and “Autonomous” stages. Similarly, on the first stage, learner's goal is to develop an understanding of movement's requirements. The additional thing against Fitts & Posner's theory is that a learner has to learn to discriminate between regulatory and non-regulatory conditions. According to the conditions, each skill is described as “Closed Skill” and “Open Skill”. As the second step, on the basis of difference between skills, Fixation means a training of “Closed skill” which refines movement patterns. Conversely, diversification denotes a training of “Open Skill” which adapts movement to conform to ever-changing environmental demands. Thus, in the case of tennis, serve is “Closed Skill” which a learner has self-control in respect to the ball and racket. However, smash is regarded as “Open Skill” because a learner must shot the return-shot ball from the opponent.

2.2 *Interactive Learning of Sports Skill for Personal Training*

Interactive learning of sports skill is implemented by means of bio-feedback as improvement instruction based on specified activity data. Several advanced studies for personal training obtained significant findings.

Kawagoe et al. (2011) developed the feedback system which visualizes a center of gravity from learner's motion by using motion capture. A Learner can check her/his center in addition to motion and

posture after the trial. The study focused on the non-supervised / autonomous training based on cycle between personal exercise and reflective learning. The result of experiment for serve skills of novice badminton players shows some effect for understanding the relationship between the center of gravity and the movements of the learners.

On the other hand, Gotoda et al. (2011) proposed real-time coaching between a learner and an expert as supervisor via internet during training. They tackled to remote coaching system of runner's arm-swinging form with wireless sensor devices. The system provides coach for monitoring interface on web browser in real-time. The simple instruction by coach's mouse-click operation among several preset candidates on the browser is transmitted to sensor device as sound feedback. The practical experiment led to the possibility of real-time feedback training system to improve motion patterns based on several obvious problems.

In comparison with these studies using the dedicated devices and sensors, Matsuura et al. (2009) proposed personal web-training system with video recording devices which everyone can get easily (e.g. digital camera, mobile phone integrated with camera etc.). Learners can upload their training video into the community site which has the video-sharing and video-analysis function. The system analyzes human body-motion in the uploaded video by using Open CV and visualized it as a chart upon the video screen layer. Additionally, the system recommends several video candidates as supervised learning material for after the upload and analysis. The candidates are based on all video archives of same type of skill which has uploaded. The framework made users learn without burden.

2.3 Discussion on These Studies

Regarding the novice level in tennis, to make an appropriate contact with the ball is first step up the ladder of skill training for the novices. Both serve and smash which held up as examples are a basic technique with it, and they can practice on their own. Therefore we choose them as targeted skills. Based on Fitts & Ponsner theory, in the case of these skills, strategy of movement patterns in Cognitive stage is simple like abovementioned patterns only from the aspect of contact with proper timing. Thus, the system focuses on supports between Associative and Autonomous stages. However, Gentile theory suggested the consideration of environmental steadiness. In fact, generally, Open Skill: smash is more skillful than Closed Skill: serve. For this reason, we define a flow of two principal stages as learning scenario.

As to the requirement, fundamental idea is to avoid excessive fatigue for novice practice. The demands include the training without attached devices. Moreover, the ideal contact timing does not depend on individuals except for the body-height differences while the control of gravity position based on movement sequence is diversified. Therefore, we chose interactive learning with an image-processing analysis and real-time feedback for the obvious problem.

According to the discussion, we designed two stage learning scenario from Closed Skill: serve to Open Skill: overhead smash. Our system contributes to accomplish the problem of each stage step by step.

3. Learning Scenario

Figure 1 illustrates the learning scenario. On the first step, a learner practices toss which throws the ball overhead before shot training because at least both enough height and straight toss in a vertical direction brings condition to measure the appropriate timing for a learner. Next step, a learner conducts serve training. The system helps this shot timing after self-toss. S/he practices this step over and over until acquisition of correct contact timing. After that, in the Open Skill stage, a step without shot is prepared in similar to Closed Skill. However, the move training represents a completely different approach to it. A learner has to predict where the ball from a toss machine which has a role in opponent will land. Finally, when a learner is ready to handle the movement base on prediction, s/he tries to do smash training with feedback.

At the beginning, we focus on closed skill stage. In the following sections, the system design and experiment s plan concentrating on Closed Skill training will be presented.

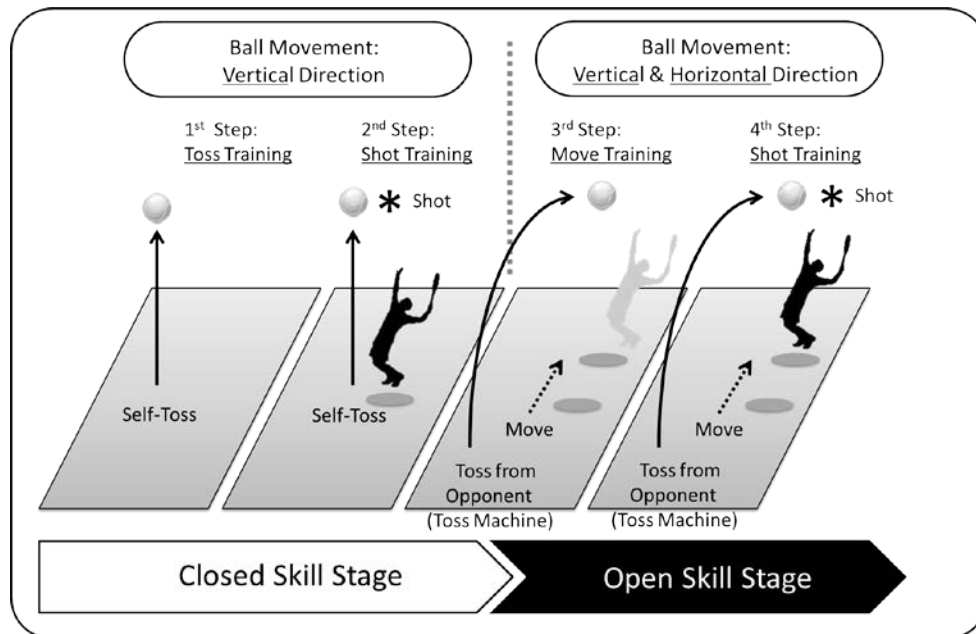


Figure 1. Learning Scenario

4. System Design

Shot-timing feedback is based on trajectory prediction of the tennis ball. The prediction is conducted by analyzing an initial section of captured video frames. Figure 2 shows derivation rule of appropriate contact height which corresponds to the timing. Image-processing module with Open CV analyzes several video frames from release point. The system extracts velocity vector based on interval between frames and develops the estimated expression for the ball position.

Next, as shown in example like Figure 3, height including appropriate contact area is shown as colored ball by video projection. On the basis of the premise that system knows exactly proper contact position including body height and arm length by image processing with Open CV library, the graduated pattern composed several different color bands is provided by analysis vertical movement of the ball along with the predictive trajectory. Moreover, the band width is depended on accuracy because expert can contact it almost exactly within the thin area. Therefore, the width is adjusted in accordance with learner's skill level or learning progress.

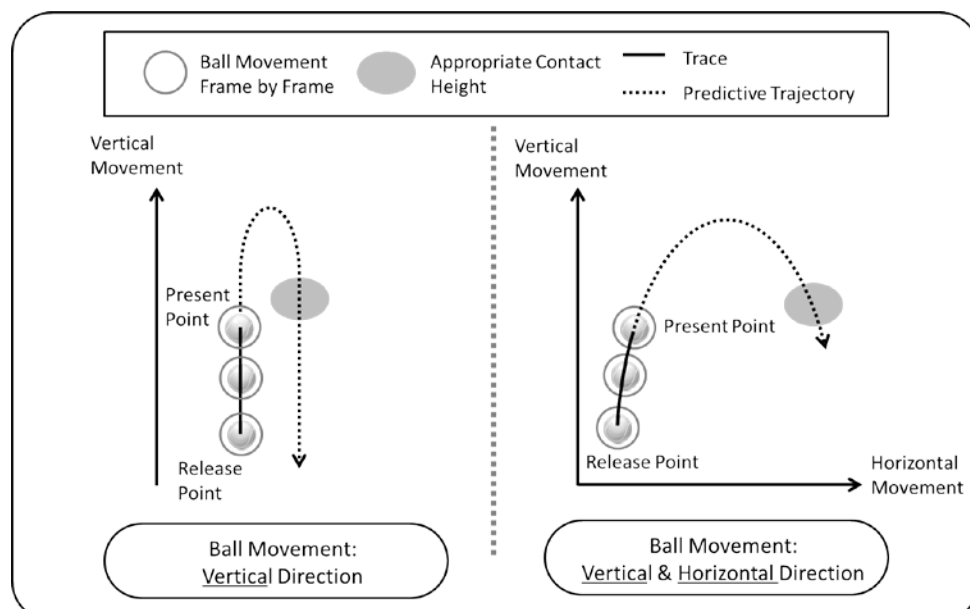


Figure 2. Trajectory Prediction of Tennis Ball

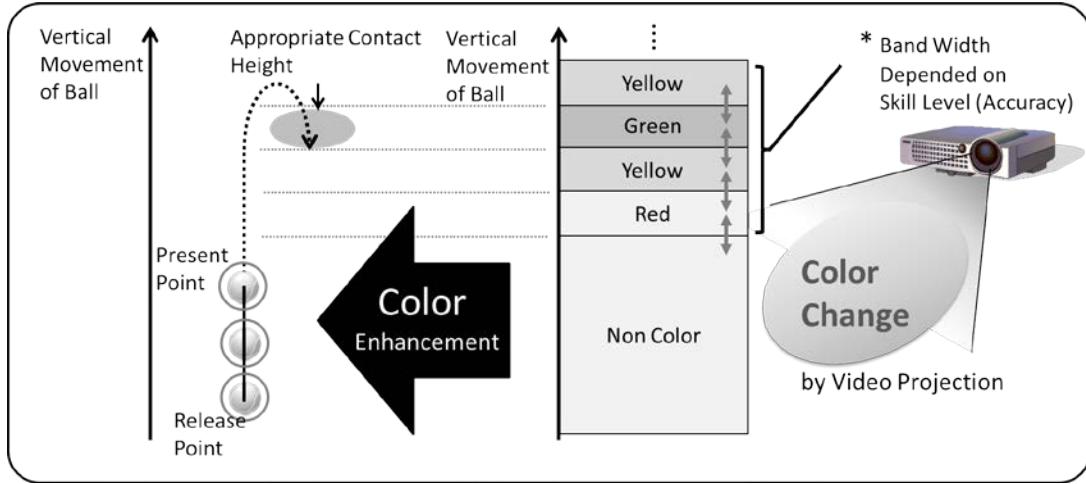


Figure 3. Example of Color-change Model for Shot Training

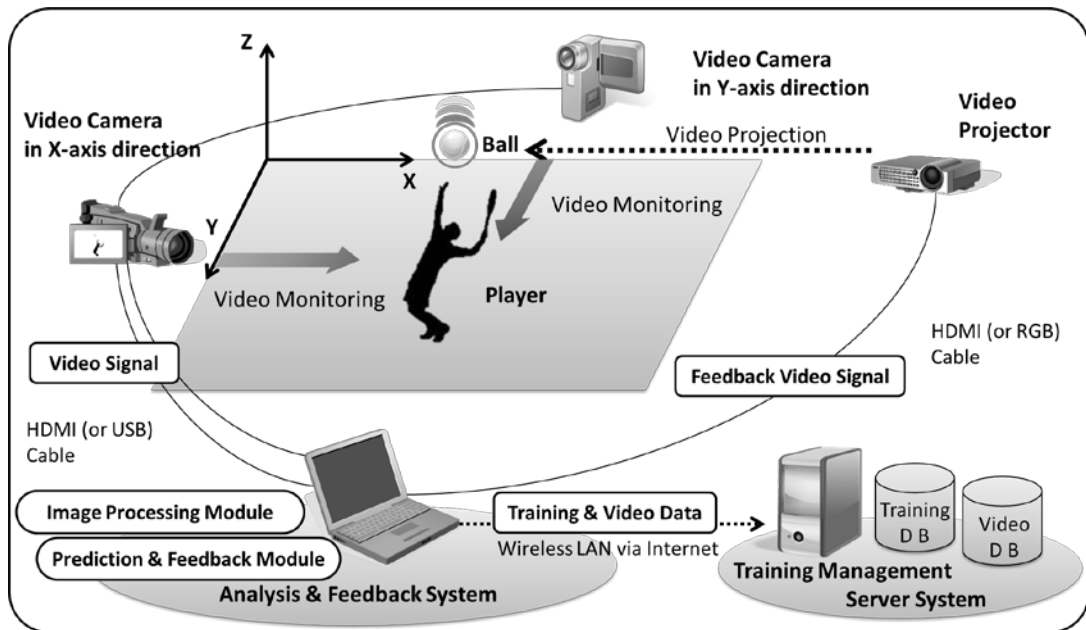


Figure 4. System Configuration (i.e. Closed Skill: Serve)

Figure 4 denotes an overview of system configuration based on these architectures. Monitoring function is set up composed of two cameras which the X intersects with Y at player's place. Analysis and feedback system runs the image processing, prediction and feedback modules while sending the data to the training-management server.

5. Experiments Plan

Experiments based on our proposal will be conducted under the process like Figure 5. First of all, we will ensure the reliability of training system to establish the support method. Therefore, predictive trajectory of the ball will be compared with the real trajectory to monitor the position precisely for the immediate feedback. Shot timing based on our enhancement model will be compared with real shot timing by experts in the latter evaluation. This focus on an investigation of validity related to feedback. In particular, a color-change order and the band width will be defined by the supervised opinions.

After these preliminary experiments, we are going to evaluate the learning effect with the established method for novice learners. In the process of evaluation, timing accuracy is treated as reference index to judge learner's skill level. Therefore, the variation tendency will be investigated through a comparison between novice-player group and expert-player ones of several skill levels. Finally, we will prepare comparative approaches: with the method and without it. The effect difference

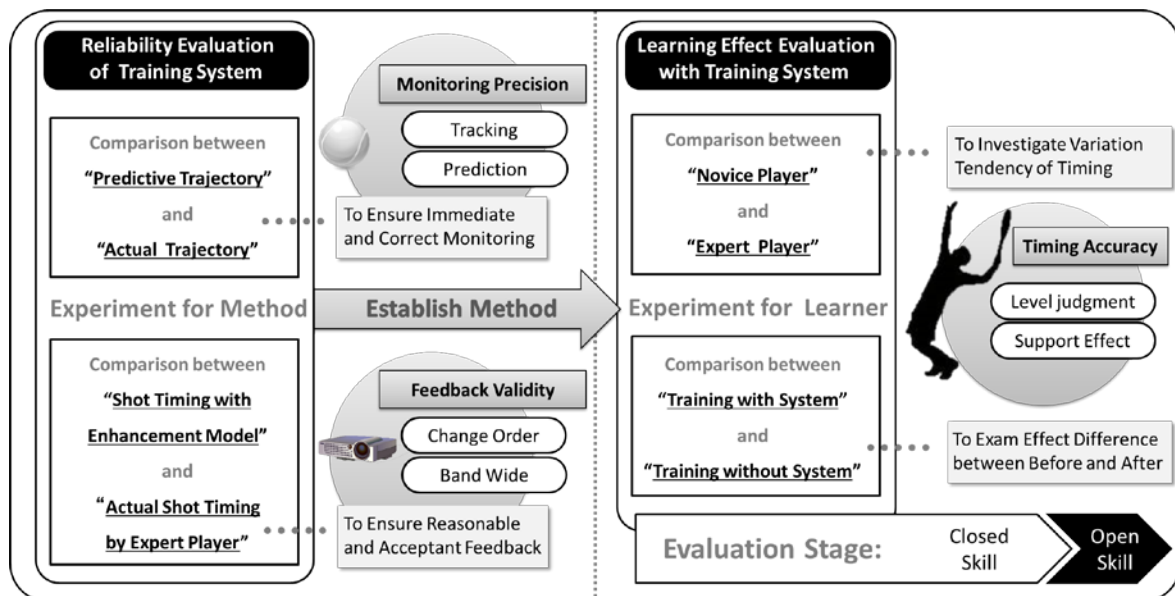


Figure 5. Experiment Process

between before and after will be shown through training results based on each environment. After the experiment regarding Closed Skill, Open Skill stage will be done with improved method.

6. Conclusion

We proposed a real-time feedback system of shot timing in tennis. The appropriate contact area is shown as colored ball by video projection. The graduated pattern composed several different color bands is provided by analysis vertical movement of the ball along with the predictive trajectory. The width is adjusted in accordance with learner's skill level or learning progress. In the near future, we will implement our proposal and conduct the experimentation. Also, we will define concrete patterns of color-change through trial and error. Also, after training experiment of Closed Skill, we will develop additional feedback for smash position in the training of Open Skill.

Acknowledgements

This work was supported by JSPS KAKENHI Grant Number 25750097 and Nakajima Foundation.

References

- Eureka Computer Co., Ltd (2010). e-Sports Ground. <http://www.esportsground.com/> (accessed Aug. 7, 2013).
- Bernstein, N.A. (1996). With on Dexterity and its Development. Latash, M.L. and Turvey, M.T. (eds.), *Lawrence Erlbaum Associates Inc.*
- Fitts, P.M. & Possner, M.I. (1967) Human Performance. Oxford, England: Brooks and Cole.
- Gentile, A. M. (1972). A Working Model of Skill Acquisition with Application to Teaching. *Quest*, 17, 3-23.
- Kawagoe, T., Soga, M., & Taki, H., (2011). Development of Motion Visualization System with Center of Gravity for Novice Learners of Motor Skills. *The 25 Annual Conference of the Japanese Society for Artificial Intelligence*, 3D2-0S8.
- Gotoda, N., Matsuura, K., Otsuka, S., Tanaka, T., & Yoneo Yano (2011) Remote Coaching System for Runner's Form with Wearable Wireless Sensor. *International Journal of Mobile Learning and Organisation*, 5(3-4), 282-298.
- Matsuura, K., Gotoda, N., Nabeshima, T., & Yano, Y. (2009). Physical Skill Development in a Technology-Enhanced Community Site. *Proceedings of International Conference on Cognition and Exploratory Learning in Digital Age*, 511-512, Rome, Italy: IADIS Press.

Training-Course Design for General Purpose of Motor-Skill Learners on a Web

KenjiMATSUURA^{a*}, Hirofumi INUI^b, KazuhideKANENISHI^c&HirokiMORIGUCHI^d

^a*Center for Administration of IT, The University of Tokushima, Japan*

^b*Graduate School of Advanced Technology and Science, The University of Tokushima, Japan*

^c*Center for University Extension, The University of Tokushima, Japan*

^d*Institute of Health Biosciences, The University of Tokushima, Japan*

*ma2@tokushima-u.ac.jp

Abstract: In this paper, we describe the new proposal whose objective is to present an online environment for physical skill learning. Our target skill is not only an intellectual one but also gross motor-skills such as rope-skipping and running. We developed a courseware system that covers wide areas of such skills because its general framework is based on the common taxonomy about the physical skills. With the supporting scenario, the system navigates learners to an appropriate direction from the novice task to the expert one.

Keywords: Motor skill, web system, Gentile taxonomy, navigation

1. Introduction

Most of human abilities in intellectual domains are not innate and both of quantity and quality of them always grow up by way of specific efforts such as drill-practice in mathematics. When we deal with “skill” in an academic context, it is regarded as a posteriori ability whose mechanism and its learning process are much complex. Further, physical skills or motor-skills also require periodic practices of repeating actions as well (Jarvis, 1994).

There are several studies that deal with a skill-development with the objectives for sustainable training rather than spontaneous motivation of improving human’s ability. Being similar to them, motor-skill development is regarded in both academic fields and practical situations where many contexts arise depending on both individuals and environments. Therefore, a general taxonomy for common use is required as a principle.

By the way, skill science has a long history as an academic interdisciplinary field where it is related to other fields such as learning science and cognitive science (Schmidt, 1975). A lot of major theories are derived from it and others incorporated to this field mutually. In concrete, “Schema-theory” influenced many following studies on sport-science as a potential prediction-model that tries to explain human ability in facing inexperienced problems.

The other applied areas of the field cover widely such in brain-science or control model of motor-actions, training menu or analytics of motions in sports and so forth. In respect to physical learning domain, many approaches combine sports-science and learning-science. The outcomes of them sometimes contribute to physiotherapy and other practical area.

Most of the skill transferring media from one to another is language. Skill itself is commonly said as practical actions in acquisition and development of the higher knowledge and motor-actions that are acquired only in case learners practice them repeatedly. In this sense, the meaning of skill always involves relative perspectives interpersonally. In addition, it sometimes implies potential change as well as the performance/reaction change as seen in personnel growth. The major stream of growth takes place by the direct experience of practice or the empirical impact in the real situation. However, some skills are developed through the indirect experiences that are transferred by a linguistic way. The audio and visual media in addition to the language become more popular than ever before because of the rapid expansion of social traffic on the Internet.

One of the sophisticated researches for acquisition and development of motor-skill is a linguistic approach that incorporates meta-recognition. Metacognition is a complex concept but today’s

major stream in this area because it expresses the intuitive relationship between consciousness and a motion trajectory. However, in this approach, the verbalizing by metacognition does not denote its objectives as "holding the consistency and correctness". The essential meaning in metacognition of motor-skill is "the tool for discovery". It claims that an appropriate environment is required in understanding the relations between surrounding environment and the physical activity in order to discover new facts in sustainable practices. It is not limited to the individual. A framework to share the facts or the didactic experience with others has been paid attention in the online community. For the sake of the fascinating translation of understanding facts with linguistic way, the social network is used these days (Wenger et al., 2009). Based on the background discussion described above, as an aiding the support of physical skills acquisition and development, we apply the web community environment (Matsuura et al., 2011).

The target of our approach is to propose general framework for courseware tools about motor-skill development on the web. As a concrete proposal, well-known taxonomy is adopted that is described in the next section to start with.

2. General Classification of Motor-Skills

2.1 Taxonomy

Domain fields for motor-skill have been spreading widely. Some of them can be evaluated indirectly by the performance data. It is collected in an experiment of the practical fields. Arts or cooking are typical examples on behalf of these skill fields because they are available to be measured by way of the products in addition to the motion analysis.

The challenging attempt in this area is to classify them with common criteria. One option is the length of the trial time for physical motions while many researches focus on intelligence, didactics and senses such in arts (Soga, et al., 2012) or medical fields (Knight, 1998, Majima, et al., 2012). Even being limited within sports, there are long-term skills and short-term ones from a viewpoint of motion time. With the rapid progress of sensing technologies, analytical approaches on short-term skills are paid attention gradually (Kishimoto et al., 2012). Ball kick in football (Williams and Reilly, 2000), hockey (Stephen, et al., 2004) and table tennis (Maaty, et al., 2011) are typical examples in such fields. On the other hand, we focus on long-term skill that comprises the series of motions. Our concrete target-motions are rope-skipping or juggling ball of which actions need repeating actions.

Skill acquisition in short-term category sometimes has its breakthrough trigger, which is hard to catch up with the system automatically because of its unexplained mechanism. On contrary, skills in long-term category often require matured practices of many times. In addition, some skills have their systematic process from the easiest one to more complex one. For example, rope-skipping techniques usually start with overcoming the basic jump. Then, one who mastered the basic jump proceeds to the next stage such in alternate foot jumping or front-back cross and so forth. Since such a process has the common direction from the basic one to the complex one, we can make subdivision and materialization of the conceptual skill in a supporting system.

The well-known discussion on general taxonomy of the growth process derives from Gentile (Gentile 1972). It has two basic axis thereof; i.e. (a) environmental context and (b) function of actions. Environmental context (a) can be divided into further two types with two variability; in-motion and inter-trial with whether the same condition are set or not. Likewise in terms of (b), two variability in two further subdivision are proposed wherein object manipulation is required or not. The overall criteria are listed up in table 1.

Combining these items make us enable to set up two dimensional subdivision table with total sixteen cells therein. Some researchers suggest the application about the table that helps step-by-step development is feasible and then the performance through the process can be improved. Therefore, we adopted the two dimensional taxonomy for supporting skill development framework. In addition, we propose the navigating strategy for learners in this general framework. The system itself is designed and implemented on a social networking system that is available to offer members to communicate among them.

Table 7: Criteria in Gentile's general taxonomy of motor-skills

No	Item	Axis description
(1)	In-motion & same condition	(a)
(2)	Inter-trial & same condition	(a)
(3)	In-motion & different condition	(a)
(4)	Inter-trial & different condition	(a)
(5)	Manipulating object none & Moving from the original position	(b)
(6)	Manipulating object exist & Moving from the original position	(b)
(7)	Manipulating object none & Keeping the standing position	(b)
(8)	Manipulating object exist & Keeping the standing position	(b)

2.2 Task assignment

Following to the introduction of the general taxonomy, Table2 illustrates the assigned cells in a whole process. The number in each cell refers those in Table 1. To start with, the easiest skill-level is located in ((1)&(5)) where novice learner should begin the training. The most complex one is in ((4)&(8)) where the learner completes overall training with this courseware.

An organizer of the total training selects the total skill. Then s/he can subdivide it in each cell based on the combination of each item of criteria. When the content in ((1)&(5)) is defined by the organizer, the other cell-contents can be systematically fulfilled. For example with skipping-rope of single, the first goal of the subdivided training might be “keep jumping at constant timing at fixed location without rope”. Then, the final goal of the last training might be “alternate step-jumping with a rope at inconstant rhythm served by the third person with moving location”.

Table 8: Whole view of Gentile taxonomy

			(b)Function of actions			
			NOT Moving		Moving	
			NOT Manipulate obj.	Manipulate obj.	NOT Manipulate obj.	Manipulate obj.
(a)Environm ental context	Same cond.	In-motion	(1)&(5)	(1)&(6)	(1)&(7)	(1)&(8)
		Inter-trial	(2)&(5)	(2)&(6)	(2)&(7)	(2)&(8)
	Diff. cond.	In-motion	(3)&(5)	(3)&(6)	(3)&(7)	(3)&(8)
		Inter-trial	(4)&(5)	(4)&(6)	(4)&(7)	(4)&(8)

In practical situation, the organizer does not have to fulfill all the sixteen cells in an affected manner. The organizer should design them as a feasible context without any unnatural manner. Our belief is that the important policy should be coherence in the total process. In concrete, the motion without any manipulating object such in Karate, the organizer does not need to consider the row of (6) and (8).

3. Design and Implementation

3.1 Design Principle

The basic idea to implement the navigating system along with the discussion above, we have decided to adopt the platform in SNS, Social Networking Site. The reasons are as follows;

- (1) Open source software: It is easy to customize.
- (2) Many original functions: We can use the existing tools easily.

Beyond the preserved tools by the framework of OpenPNE by Tejimaya (<http://www.openpne.jp>), we customized the community space whose functions are defined by the organizer. The organizer should design sixteen cells with contents of detail objectives and training.

3.2 *Stored data and the output data*

When content of the training in a required cell is defined, the members in a community follow the instruction. The outcome or resulting performance through the training is stored in each cell data via the web-interface. The target training method for the member is produced at every time s/he visits the community space online. If a learner as a member of the community achieved the configured performance of a cell, s/he can proceed to the next training navigated by the system automatically. In other words, a member cannot select the next target task by oneself. Furthermore, the whole view of the process in the series of the training is not elucidated from the bird's eye view. It is because some apprehension of the keeping or raising motivation in case the learner knows their current stage of the skill. In terms of required data for each cell, the organizer has to define following three forms.

- (1) Training content: Each learner has to input her/his original training method to the system every time. If the resulting performance is better than ever, the associated training should be focused later on. The combination of the result and the process is sharable with other members in order to give the hint for pull up from the plateau.
- (2) The performance data: The data is relevant to both the quality and quantity of the training. Therefore, the numeric value can be compared or calculated for the judgment of the level of achievement to the cell.
- (3) Self-evaluation: To give subjective comment, the system provides the self-evaluation form because of the necessity of supplemental data thereof.

3.3 *Estimation and Navigation*

There are a variety of route from the initial to the goal. In order to provide several options to suggest the next direction from a cell, we have to take into account of avoiding the possible contingency in the performance data rather than the data itself. In other words, with the simplicity comparison method, the learner may be able to accomplish the task "by chance", but the system should really detect the phenomena in detail a little more whether it is the really clear the subtask or not. Hence, the system offers an input-form of (2) in addition to (3) in order to get enough data at a trial time.

As a general navigating rule, the possible cells from the next three options may be chosen from eight cells which are up to choices of $(i+1, j)$, $(i, j+1)$, $(i+1, j+1)$, when a learner clears (i, j) cell. In the choice of the transition of this time, the most appropriate direction is selected depending on the history of clearing the target task. In addition, the navigating direction of the transition is possibly back to a former subtask when the learner does not clear the task. In terms of the concrete algorithm, we summarize it as follows;

- (A) If there are multiple results of the same exercise, the system divides them into several consecutive blocks and it calculates the average of each block. In this way, the possible contingency decreases. If the individual mean value exceeds against the threshold, the system permits to open the next cell for the learner. The system sets the shortest path $(i+1, j+1)$ to the complexity direction as the next transition.
- (B) Then, it is thought that the learner is achieving a subtask more or less when a few values of means are more than the threshold. In such a case, the system presents the open cell $(i+1, j)$ or $(i, j+1)$.
- (C) The system judges that the achievement of the subtask requires a little more exercise when the number of the succeeded means is less than the threshold. In such a case, the system shows a self-loop to (i, j) , otherwise it provides the possible cell as $(i-1, j+1)$ or $(i+1, j-1)$ to the next cell. These are cells at the parallel position against the direction to (4,4) cell. Gentile taxonomy does not define the firm orders in these categories.

(D) At the last case that all means are under the threshold, the system provides the negative direction to the forward because such a case seems difficult to achieve the given task. Concretely, the system suggests (i-1, j) or (I,j-1) cell to the learner.

3.4 Tailoring the training in a community

It is not limited to motor skills, but physical skills are strongly affected the individuality. Therefore, the functions for the discovery that contributes to the development of own skills are required as a general principle. For example, the equivalent function is seen in the blog space that corresponds in the SNS (Hamagami et al., 2012). To this, it may give the bright sight to solve the plateau situation. If the learner cannot improve the current skill level even with the repeating training, the motivation of her/his may be also reduced. However, the mutual exchange of the training methods of inexperience or some hints through the SNS might be the triggering opportunity to improve the current stage. For learners from the above discussion, who has remained at the same level subtasks with a certain number of exercising times, we integrate a social function to see how the others have successfully achieved the target about the same cell.

4. Trial Use

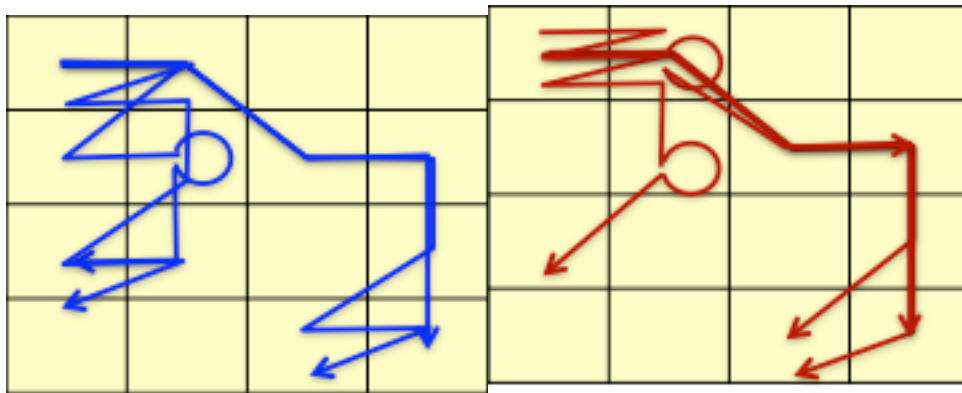


Figure 1. The path of the community members (left:juggling, right: rope-skipping).

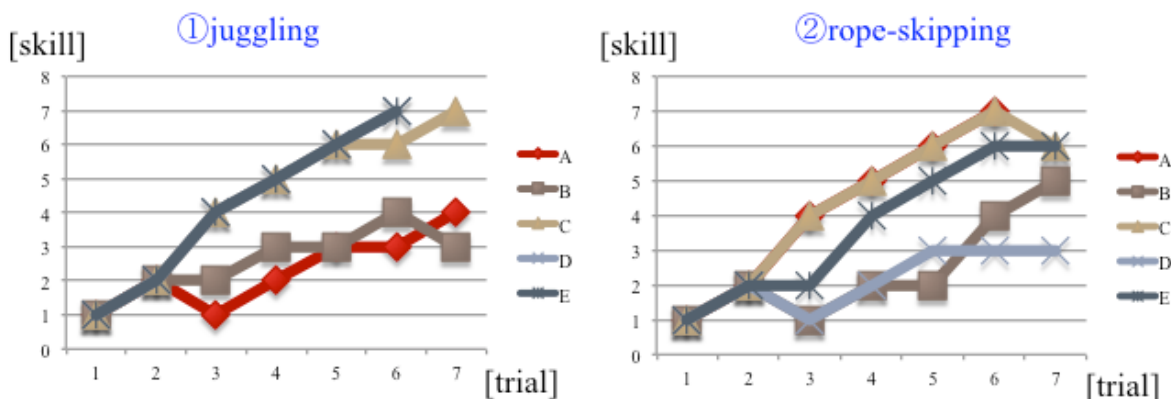


Figure 2. Learning curve following to Gentile taxonomy.

We organized the volunteer subjects for the trial use of our proposal. The number of subjects was five who have similar properties of body, age, and gender. We selected two concrete themes for the skill development that are juggling the football and rope-skipping of single. Both have the common properties that have been discussed already; i.e. long-term skill, repeating actions with manipulating objects, and so forth.

The initial levels about the target skill were almost the same on the analogy of previous interview for each. They started from (1,1) cell that presents the same task to each learner. However, the tasks other than (1,1) are different each other. As learners could not know the final goal task to complete, they follow the presented tasks step by step. The results of a traced path of the subskill process read in Figure 1. The left figure indicates the football juggling while the other one does the rope-skipping, where all the subjects' data were integrated into the same figure.

The result shows that the navigation in our general courseware led the learners to the goal properly. Some of them had difficulties to proceed directly to the next positive path; otherwise the others had no problem in terms of the difficulties configured by the organizer. With the taxonomy, the lined cells drawn at a slant from upper-right to lower-left are regarded as the same level. Therefore, when we plot the skill level to be summarized by the result in Figure 1, we got Figure 2 as an implying learning curve in the skill development. From this, most of the subjects gradually proceeded to the final task although they stayed a bit at the same or negative stage for a while.

5. Concluding Remarks

In this paper, we discussed the new proposal for training method of motor skills in the online community environment. Although the current project is still in an ongoing stage, we have developed the prototype system. Using the system, we made some observation and reported obtained data about the growing learners along with our scenario on the social web environment.

We can continuously discuss the future implications as following further issues. We will tackle these themes from now on.

- (i) Distinguishing performance from the training
- (ii) Integrating adaptation method from technical perspectives
- (iii) Effective feedback based on direct motion data

Acknowledgements

This work was supported by JSPS KAKENHI Grant Number 23501150.

References

- Abu Maaty, M.T. and Adib J.N. (2011). Effect of Using Closed Loop Theory on Performance Level of Some Basic Skills of Table Tennis Juniors, *World Journal of Sport Sciences*, 5(2), 131-134.
- Carolyn M. knight (1998). Evaluating a skills centre: learning psychomotor skills – a review of the theory, *Nurse Education Today*, 18, 448-454.
- Seo, D., Kim, E., Fahs, C.A., Rossow, L., Young, K., et al. (2012). Reliability of the one-repetition maximum test based on muscle group and gender, *Journal of Sports Science and Medicine*, 11, 221-225.
- Wenger, E., White, N., Smith, J.D. (2009). *Digital Habitats - stewarding technology for communities* –, CPsquare.
- Gentile A.M. (1972). A Working Model of Skill Acquisition with Application to Teaching, *Quest*, 17(1), 3-23.
- Hamagami, K., Matsuura, K., Kanenishi, K. and Gotoda, N. (2012). Support on Repeating Skill Development - Modulating from monitored data to a target, *Workshop Proceedings of the 20th ICCE*, 491-498.
- Matsuura, K., Gotoda, N., Ueta, T. and Yano, Y. (2011). Design of the Community Site for Supporting Multiple Motor-Skill Development, in *Toyohide Watanabe and Lakhmi C. Jain (Eds.) Innovations in Intelligent Machine-2*, 215-224, Springer-Verlag.
- Kishimoto, K., Lynch, R.P., Regier, J. and Yingling, V.R. (2012). Short-term jump activity on bone metabolism in female college-aged non-athletes, *Journal of Sports Science and Medicine*, 11, 31-38.
- Soga, M., Ishii, K., Nishino, T. and Taki, H. (2012). A New Method for Non-Dominant Motion Skill Learning by Using Motion Navigator, *Proceedings of KES2012*, 953-959.
- Schmidt, R.A. (1975). A Schema Theory of Discrete Motor Skill Learning, *Psychological Review*, 82(4), 225-260.
- Martell, S. and Vickers, J.N. (2004). Gaze characteristics of elite and near-elite athletes in ice hockey defensive tactics, *Human Movement Science*, 22, 689-712.

- Jarus, T.(1994). Motor Learning and Occupational Therapy: The Organization of Practice, *The American Journal of Occupational Therapy*, 48(9), 810-816.
- Williams, A.M. and Reilly, T. (2000). Talent identification and development in soccer, *Journal of Sports Sciences*, 18, 657-667.
- Majima, Y., Sakoda, M.,Maekawa, Y.and Soga, M.(2012). Evaluation of Nursing Skills Acquisition of Reflective e-Learning System for Nursing Students by Different Learning Methods, *Workshop Proceedings of the 20th ICCE*,460-467.

Feedback of Flying Disc Throw with Kinect: Improved Experiment

Yasuhisa TAMURA^{a*}, Masataka UEHARA^b, Taro MARUYAMA^a & Takeshi SHIMA^c

^a*Department of Information and Communication Sciences, Sophia University, Japan*

^b*Graduate School of Information and Communication Sciences, Sophia University, Japan*

^c*Department of Health and Physical Education, Sophia University, Japan*

*ytamura@sophia.ac.jp

Abstract: This paper shows an improved experiment result of a feedback system for flying disc learners with use of Kinect device. Compared with conventional 3-D motion capture systems, Kinect has advantages of cost, easy system development and operation. Our formerly proposed system in Yamaoka (2013) captures learners' specific 20 points in 3-D manner, judges their postures and motions based on criteria defined by a domain expert, and displays feedback messages to improve their motions. An improved experiment increases the time of flying disc throw in pre-test (10 to 30) and test (5 to 10). This change allows testees to be accustomed with disc throwing activity in experimental environment, and also to master given feedback message. As a result, relatively novice testees of the target group showed significant improvement of their throwing motions.

Keywords: Flying disc, throwing movement, Kinect, capture, feedback

1. Introduction

In the field of sports science research, kinematic analysis of human body became popular in the last decade. Barris (2008) surveyed vision-based motion analysis researches for sports. Moeslund (2006) surveyed vision-based human motion capture / analysis systems. Miles (2012) surveyed applications of Virtual Reality environments for ball sports. There are wide variety of equipments adopted in these researches: GPS sensor, acceleration sensor, muscle sensor, HMD (Head Mound Display) etc. Among them, the major equipments are so called "motion capture systems", that measure many points of human body in three-dimensional space. Also the systems archive 3-D information along timeline. However, the major motion capture systems are extremely expensive, costing several hundred thousand dollars. Additionally, they require dedicated rooms, multiple cameras, special lighting capacity and dedicated "tracking suits" to specify a tracking points of human body. Furthermore, myriad steps are necessary to set up and data acquisition including the activity called "calibration", which adjusts the 3-D points of marking sensors on the tracking suit. As a result, this kind of analysis is infrequently performed outside of specialized research or specific studies of top athletes.

In contrast, Kinect device released by Microsoft Corporation in 2010 offers a simple and inexpensive way to perform 3-D analysis of a human body movement. First, the device itself costs only U.S.\$110, which is far cheaper than conventional motion capture systems. Second, Kinect is capable of capturing data easily. It does not need any tracking suits nor complex set-up and operation procedure for data acquisition. Third, Microsoft has publicly released a software development kit (SDK) that includes the necessary library for data acquisition using Kinect. Application system developers are able to write customized Windows applications with use of this library in the C# or C++ languages.

The proposed research in this paper has 3 major points below:

- (1) Utilizes Kinect
- (2) Captures 3-D motion and give feedback to sports learners
- (3) Target motion: flying disc throw

There are many preceding researches to analyze human body motion with use of motion capture systems including Kinect. Also, there are some researches to give automatic feedback messages

to learners to refine their motion. The authors arranged these researches as shown in Table 1 in order to survey categories (1) and (2).

Table 1: Preceding researches

	Analysis	Feedback
Commercial/ Original 3D Motion CaptureSystem	Bideau (2004) Brodie (2008) Corazza (2006) Hachimura (2004)	Ishii (2011) Kwon (2005) Soga (2008)
Microsoft Kinect	Fujimoto (2012) Hsu (2011) Kato (2012) Marquardt (2012) Mitchell (2011) Ogawa (2012)	Chye (2012)

Papers at upper left side in Table 1 utilize commercial or original 3D motion capture systems to analyze 3-D motion. Bideau (2004) utilized Vicon 370 system to analyze relationship of movement between throwers and a goalkeeper of handball. Brodie (2008) synthesized a body model of a ski racer from GPS information and video motion graphics. Corazza (2006) synthesized a body model with use of 8 motion cameras and replays it in a virtual environment. Hachimura (2004) developed a dance training support system with use of magnetic sensor system Fastrak and HMD.

At upper right side, there are researches to give feedback messages to learners, based on 3-D captured data. Ishii (2011) utilized a motion capture system IGS-190 for baseball batting movement. It also provided a comparing function between “goal motion” and learner’s one. Based on the comparison, the system showed messages to refine learner’s motion. Kwon (2005) developed an original motion capture system for Taekwondo training. It also displayed a visual feedback to adjust one’s movement. Soga (2008) proposed a training support system for rhythmic gymnastics. It adopted an optical motion capture system, compared the captured data and ideal motion data, and displayed feedback messages in the screen.

At lower left side in Table 1, there are researches to analyze human motion with use of Kinect. Fujimoto (2012) developed a dance training support system. It showed learner’s image and instructor’s ideal motion image in overlaying manner. Hsu (2011) discussed many possibilities of Kinect utilization in various sports learning activities. Kato (2012) developed a system to compare a professional player and a novice learner of soccer. Marquardt (2012) diagnosed a pose of ballet dancer with use of Kinect. It is called “Super Mirror”, because common ballet studios use a mirror to check and adjust one’s pose. Mitchell (2011) developed a Kinect based system to diagnose hand movement for playground game. Ogawa (2012) developed a distance learning system. An instructor and a learner share a common virtual space, and compare their body motions.

Finally, at the lower right side, there is one preceding research similar to the proposing method. Chye (2012) utilized Kinect to diagnose Karate pose. He compared 4 joint points of an instructor and a learner, calculated their Euclid distances, and gave feedback messages to the learner.

As mentioned in the third point written above, this research focuses on the motion of flying disc throw. The authors have previously published research on the movement itself (Shima 1992, 1994, 1996, 2000). Also the authors applied these results to actual physical education tasks through the development of multimedia teaching materials (Shima 2002, 2004). Beyond them, Sasakawa (2011) analyzed the throwing motion, while Koyanagi (2010) formularized the characteristics of the applicable movement with use of a disc with an inertial sensor. Murayama (2006) conducted research on guidance using an instantaneous feedback system, while Takeuchi (2010) conducted analysis with use of a motion capture system.

This paper proposes a real time, 3-D motion capture and feedback system using Kinect, which targets novice learners to throw a flying disc. The system allows the learners to observe their own movements through video playback in real time. Also it diagnoses their joint movement and gives feedback messages automatically on their throwing form. Practiced use of the proposed system will give learners a visceral grasp of the correct throwing form, which will in turn lead to improved accuracy of throwing performance. In addition, if employed as part of physical education instruction, it is

expected that the system will aid instructors in providing individualized critique to learners and will contribute to the efficiency of the instructional environment.

2. Proposed System

The proposed system will process data in three steps: (a) acquisition of 2-D video images and position data for each point; (b) assessment of whether the flying disc throwing movement is correct or incorrect based on the Position data acquired for each point; and (c) display of feedback messages with 2-D motion images from (a) based on the results of the assessment in (b). Details of each process step are given below.

2.1 Kinect and its Data Acquisition

Kinect is a device with a function to analyze the motion of human subjects in 3-D manner. It was initially developed as a peripheral device to be connected to Microsoft's Xbox gaming system. Kinect includes a CMOS camera, infrared projector, image depth sensor, microphone, and one USB port for connection to a Windows PC. Kinect projects patterned infrared rays that are analyzed by its CMOS camera to recognize the distance between the player and the device. Also, through the machine learning function called "human pose estimation" developed by Microsoft Research Cambridge, Kinect is able to recognize the positions of subjects' joints with reasonable accuracy. The coordinates of each point detected by Kinect can be read into a Windows PC using the library included in the device's SDK.

In order to acquire Kinect data, called "SkeletonStream" properties in the Kinect SDK library must be enabled. The coordinate data for each point is extracted from the data structure called "Kinect.JointType", which is also available in the library. Point coordinate data values can be used to measure one's motion in real time.

2.2 Assessment of Throwing Form

This paper is interested in the assessment of flying disc throw movement. However, the skill levels of learners are hugely diverse, with intermediate learners and above representing the most difficult subjects to biomechanically assess. Consequently, this study focused on absolute beginners and made assessments by comparing whether or not their throws matched a basic standard throwing motion.

When processing the assessments, the throwing movement was divided into the three phases: pre-motion (take back), motion (swing), and post-motion (release). Assuming a right-handed thrower, the phase is judged by the following equations.

$$\begin{array}{lll} \text{Take back:} & x_{11} < x_2 & (1) \\ \text{Swing:} & x_2 \leq x_{11} < x_9 & (2) \\ \text{Release:} & x_9 \leq x_{11} & (3) \end{array}$$

These numbers of 2, 9, or 11 are the identifiers of specific body parts defined by Microsoft Kinect, shown in Figure 1. Also, 'X' represents horizontal coordinates, with movement in the direction of the right hand receiving a positive value. In the pre-motion phase, the take back phase, the thrower's right hand is left of the body's center; in the motion phase, the thrower's right hand is between the body's center and the elbow; and in the post-motion phase, the finish, the thrower's right hand is to the right of the right elbow. Figure 2 shows graphics of these three phases.

Next, assessments contain next five aspects: (a) enough take back (before the throw), (b) adequate height of the right hand, (c) height transition of the right hand, (d) adequate angle of the right elbow, and (e) enough twisting of the waist.

The aspect (a) is judged whether the movement contains the take back phase before the swing phase. A novice thrower tends to have insufficient take back and have a throwing motion like a ring toss. In order to prevent this error, the thrower should have a proper take back motion before the throw.

The aspect (b) is relevant to all phases of the throw. It assesses whether the right hand is properly below the level of the shoulder but above the solar plexus. The judgment is expressed by equation (4). Novices tend to allow their right hand to rise above their shoulder.

Hence this assessment is effective for spotting this error.

$$y1 < y11 < y2 \quad (4)$$

‘Y’ represents vertical coordinates. The aspect (c) is similar to (b) and assesses movement patterns that tend to prevent the disc from flying parallel to the ground, such as a throw that bows upward or downward, or a throw that swings upward. In concrete terms, if the position of the right hand is analyzed for each phase, the following judgments can be made as equations (5)-(7). Here “Low” means $y11 < y1$, “OK” means $y1 \leq y11 < y2$, and “High” means $y11 \geq y2$, while “y1” means height of “Spine”, numbered part in Figure 1.

Bowing upward: (OK or Low in take back) & (High in swing) & (OK or Low in release) (5)

Bowing downward: (OK or High in take back) & (Low in swing) & (OK or High in release) (6)

Swinging: (Low in take back) & (High in release) (7)

The aspect (d) assesses whether the angle made by the right shoulder, right elbow, and right wrist is 120 degrees or greater during the swing phase. Some novices tend to fully extend their arm when throwing the disc, causing them to lose the angle of the elbow that helps produce speed and spin.

The aspect (e) assesses whether there is sufficient twist in the waist during the take back phase. In the x-z planes, tangents for the right and left foot vector (14, 18) and waist vector (12, 16) are calculated. Specifically, the following conditional equations (8)-(10) are used.

$$m1 = (z14 - z18) / (x14 - x18) \quad (8)$$

$$m2 = (z12 - z16) / (x12 - x16) \quad (9)$$

$$\text{if } (m2 - m1) / (1 + m1m2) \leq -10 \text{ deg then OK} \quad (10)$$

‘Z’ represents deep direction and the numbers show the parts in Figure 1. Under the current assessment approach, the conditions are set to require the above vectors to be parallel (that is, the above discriminant = 0).

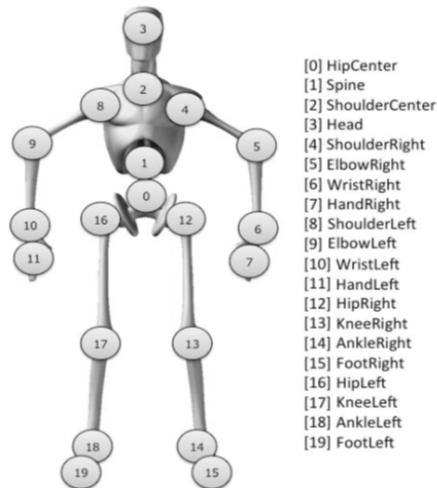


Figure 1: Numbers of Body Parts

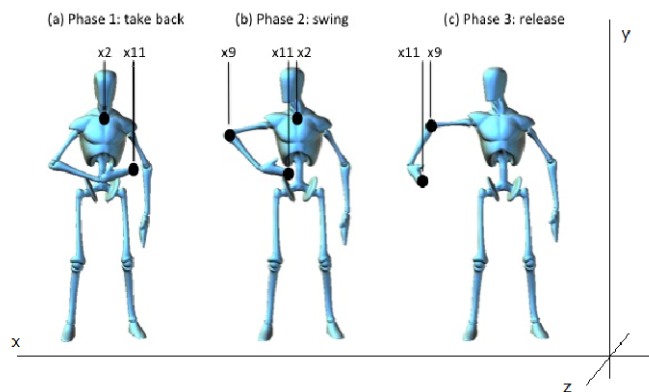


Figure 2: Phase of the Throw

2.3 Implementation

The proposing functions were implemented with use of (1) Windows PC, (2) Microsoft Official SDK (software development kit) for Kinect, and (3) Kinect device for Windows. Figure 3 shows an example screenshot of the developed system. A thrower is able to receive feedback of his throwing motion. Currently it is real time feedback, so the system is unable to play back thrower's motion later. It may cause less effect for the feedback. This playback feature is one of the future issues.

3. Experiment

In order to verify the effectiveness of the proposing system described above, the authors performed a control experiment. As stated above, this paper shows an improved experiment rather than shown in Yamaoka (2013). The major improvement is the time of flying disc throw: 10 to 30 for pre-test, and 5 to 10 for test. This change allows testees to be accustomed with disc throwing activity in experimental environment, and also to master given feedback message.

3.1 Preparation

In order to measure the preciseness of the throw, the authors prepared a large and lightweight fabric of 4m x 8m, on that 50cm wide grids were drawn. Furthermore, the target mark was drawn at the horizontal center and 1.5m up from the bottom of the fabric. This fabric was used (1) to measure the preciseness of the throw, with use of drawing grid, and (2) to project the screen of the proposed system as in Figure 3. The experiment was prepared to hang this fabric on the wall of a gymnastic hall of the university. Figure 4 shows scenery of the experiment.

The authors adopted two types of measurements. One is testee's movement with use of the proposing system. As stated in section 2.2, it has 5 aspects of qualitative assessments. In order to do it, the developed system on Windows PC, Kinect device, and LCD display were settled. The other is precision. It is measured how near a disc hits from the target mark drawn on the fabric, 7 meters from a testee. Quantitatively, a staff checked a hit point of the disc, measured both vertical and horizontal distances from the target mark, and calculated the distance from the mark.

There are two requirements for the place of the experiment: indoor place to avoid wild weather, and electronic supply nearby. In order to satisfy these conditions, the experiment was done at the central gymnastic hall of Sophia University on 24-31 July 2013. Testees were 40 undergraduate students of Sophia University, and all of them were novice learners of flying disc throw.

3.2 Procedure

First, as a pre-test, all 40 testees were examined the precision of the throws. They threw 30 flying discs to hit the target mark on the fabric. Grades (movement and precision) of all testees were measured. Next, the testees were divided into 2 groups of 20 members, which were statistically insignificant. In the pre-test, the proposing system was used to measure testees' movements, but no feedback was given to

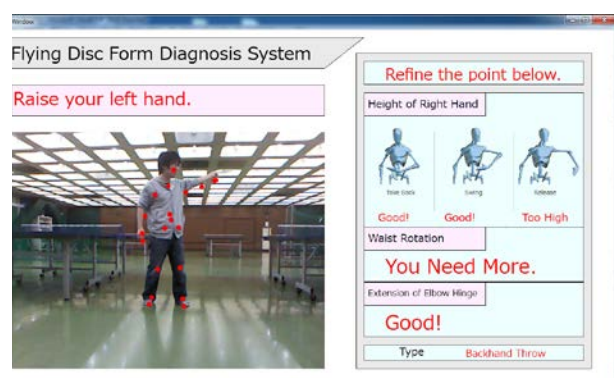


Figure 3: Sample Screenshot



Figure 4: Scenery of Experiment

testees.

Next, as a test, the target group (TG) members were given feedback in 10 times of throwing movement with use of the proposing system. As shown in Figure 4, a testee saw the visual feedback on the LCD display during throwing movement. On the other hand, the control group (CG) members had no feedback from the proposing system.

The “improvement” is to increase throwing times, 10 to 30 for pre-test and 5 to 10 for test. The last experiment didn’t show any significance, and the authors supposes the reason on insufficient feedback of throwing. Also, increase of pre-test contributes to show more precise skill level of each testee.

3.3 Result

First, whole TG (20 members) and whole CG (20 members) were compared by measure of movement, captured by Kinect. The grade is the summation of 5 criteria. The result is shown in Table 2. Based on the result, the proposing system does not effect in the feedback of testees’ motion in significance level of 5%.

In order to check the detail, the authors drew graphs of both TG and CG, that show scores of pre-test and test to arrange pre-test score in descending order. Figure 5 shows it for TG, while Figure 6 for CG. In these figures, X axes are for testee sequence, while Y axes for grades in full of 100 (each 20 points for 5 aspects (a)-(e) in Section 2.2). In Figure 5, top level testees (arranged in the left side) have no significant improvement of test scores compared with pre-test. It might mean that non-novice (intermediate) learners are not effective with use of the proposing feedback system. Based on this hypothesis, another comparison was made to omit top 5 testees of both TG and CG. In other words, comparison was made with 15 testees of both TG and CG. This result is shown in Table 3. Table 3 shows statistical significance (3.04%) in significance level of 5%. From this result, the proposing system is effective of disc throw motion improvement in relatively novice learners.

4. Discussion

While the authors are discussing the system functions and assessment criteria shown in the Section 2.2, there are some arguments below.

- Further patterns are possible in regards to the formula used for assessment aspect (c) and judgment of a throw as “bowing upward,” etc. It is necessary to add additional throwing patterns, acceptable ones and clearly erroneous ones, as we gather measurements from further experiments.
- Assessments aspects (d) and (e), judging the angle of the right elbow and the twist of the waist, respectively, are still at a trial stage. It is necessary to consider and debate their validity in light of actual throwing movements.
- Assessment aspect (e), twisting of the waist, currently is calibrated for ‘0’ waist twist even during the take back phase, which means that parallel waist and feet receive a positive assessment. Other options exist, though, such as a negative value indicating twisting of the waist.
- Currently, the feedback to the learner is given in text only. Adding audio and voice functionality will likely make the feedback more readily apparent to the learner.
- The proposing system does not treat moving speed of critical body parts. Currently it is out of focus in measurement and feedback, but should be included in the future work.

The result of experiment shows significance only for relatively novice learners. It means that there are some other feedback criteria for intermediate learners. This point is thought as one of the future issues.

5. Conclusion

This paper has presented a system with use of Kinect device for analysis of and feedback on the motion of throwing a flying disc. A result of experiment shows that this method is useful for relatively novice learners to improve their movement. Future research will work to refine the current system vis-à-vis the points noted in Section 4, and retry to validate the efficiency of the proposing system with improved methods and sequence.

Table 2: Result of t-test (1)

	TG	CG
Mean	74.14	63.82
Variance	208.2993684	350.9764211
Observations	20	20
t Stat	1.951558999	
P(T<=t) One Tail	0.029195101	
t Critical One Tail	1.304230204	
P(T<=t) Two Tail	0.058390202	
t Critical Two Tail	1.68595446	

Table 3: Result of t-test (2)

	TG (low 15)	CG (low 15)
Mean	71.17333333	58.21333333
Variance	207.6335238	276.9740952
Observations	15	15
t Stat	2.280108492	
P(T<=t) One Tail	0.015208549	
t Critical One Tail	1.701130934	
P(T<=t) Two Tail	0.030417098	
t Critical Two Tail	2.048407142	

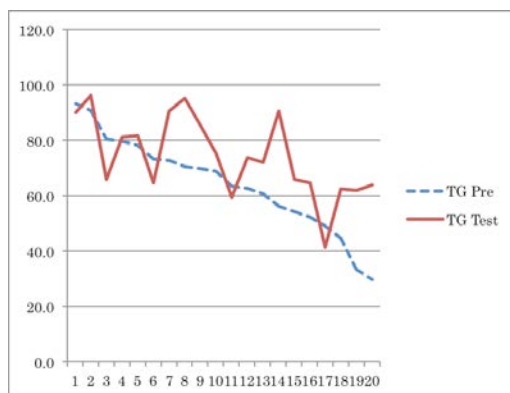


Figure 5: Ranking of Target Group

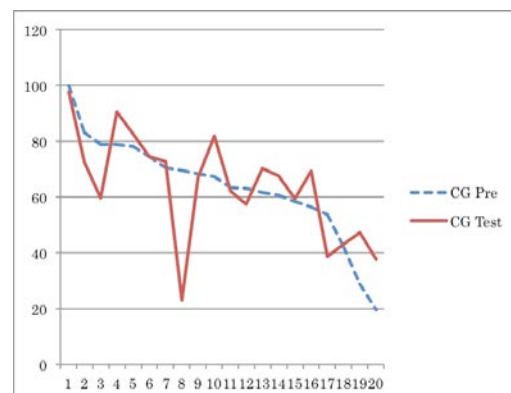


Figure 6: Ranking of Control Group

Acknowledgements

This research was partially supported by the Ministry of Education, Science, Sports and Culture, Grand-in-Aid for Scientific Research (C) 25350779, 2013.

References

- Arai, T. et al. (1993). Research on the movement of throwing a flying disc, II: Comparison of backhand and forehand throws, Proc. Congress of the Japanese Society of Physical Education, 44B, 681. (in Japanese)
- Barris, S., & Button, C. (2008). A Review of Vision-based Motion Analysis in Sport, Sports Medicine, 38(12), 1025-1043.
- Bideau, B., et al. (2004). Using virtual reality to analyze links between handball thrower kinematics and goalkeeper's reactions, Neuroscience Letters, 372(1-2), 119-122.
- Brodie, M., et al. (2008). Fusion motion capture: a prototype system using inertial measurement units and GPS for the biomechanical analysis of ski racing, Sports Technology, 1(1), 17-28.
- Chye, C., Nakajima, T. (2012). Game based approach to learn Martial Arts for Beginners, IEEE 18th International Conference on Embedded and Real-Time Computing Systems and Applications (RTCSA), 19-22.
- Corazza, S. et al. (2006). A Markerless Motion Capture System to Study Musculoskeletal Biomechanics: Visual Hull and Simulated Annealing Approach, Annals of Biomedical Engineering, 34(6), 1019-1029.

- Fujimoto, M., Terada, T. & Tsukamoto, M. (2012). A Dance Training System that Maps Self-Images onto an Instruction Video. ACHI 2012 (The Fifth International Conference on Advances in Computer-Human Interactions), IARIA, 309-314.
- Hachimura, K. et al. (2004). A Prototype Dance Training Support System with Motion Capture and Mixed Reality Technologies, Proc. IEEE International Workshop on Robot and Human Interactive Communication, 20-22.
- Hsu, H. J. (2011). The Potential of Kinect as Interactive Educational Technology, 2nd International Conference on Education and Management Technology, 13, 334-338.
- Ishii, K. et al. (2011). Proposal and development of reversal motion skill learning support environment, International Conference on Information Technology Based Higher Education and Training (ITHET), 1-6.
- Kato, K. et al. (2012). Exploring Analysis of Football Actions Considering Correlation of Joints in the Body, Ninth International Conference on Networked Sensing Systems (INSS), 11-14.
- Koyanagi, R. & Ohgi, Y. (2010). Estimation of the flying disc dynamics using the inertia sensor, The Japan Society of Mechanical Engineers Fluids Engineering Conference, 91-92 (in Japanese)
- Kwon, D. Y., Gross, M. (2005). Combining Body Sensors and Visual Sensors for Motion Training, ACM SIGCHI International Conference on Advances in computer entertainment technology, 94-101.
- Marquardt, Z. et al. (2012). Super Mirror: a kinect interface for ballet dancers. In Proceedings of the 2012 ACM annual conference extended abstracts on Human Factors in Computing Systems Extended Abstracts (CHI EA '12), 1619-1624.
- Miles, H. C., et al. (2012). A review of Virtual Environments for Training in Ball Sports, Computers & Graphics, 36, 714-726.
- Mitchell, G., Clarke, A. (2011). Capturing and Visualising Playground Games and Performance: A Wii and Kinect based Motion Capture System, Proc. Int'l Conf. Electronic Visualisation and the Arts (EVA'11), 218-225.
- Moeslund, T. B., et al. (2006). A Survey of Advances in Vision-based Human Motion Capture and Analysis, Computer Vision and Image Understanding, 104, 90-126.
- Murayama, M. et al. (2006) The effects of skills instruction using immediate feedback with moving images: Case study with flying disc side arm throws, Proc. Congress of the Japanese Society of Physical Education, Health and Sport Sciences, 57, 184. (in Japanese)
- Ogawa, T., & Kambayashi, Y. (2012). Physical Instructional Support System Using Virtual Avatars. ACHI 2012, The Fifth International Conference on Advances in Computer-Human Interactions. IARIA, 262-265.
- Sasakawa, K. (2011). A characteristic of throwing skills for distance of the sidearm throw motion in view of the change of horizontal velocities and horizontal accelerations at each joint of throwing arm and a flying disc: A comparison of skilled and unskilled Ultimate players, Chukyo University Sports Research Bulletin, 25, 1-12 (in Japanese)
- Shima, T., Arai, T. (1992). Research on the movement of throwing a flying disc, I: Backhand throws, Proc. Congress of the Japanese Society of Physical Education, 43B, 774. (in Japanese)
- Shima, T. et al. (1994). Research on the movement of throwing a flying disc, III: Comparison of straight and curved throws, Congress of the Japanese Society of Physical Education, 45, 565. (in Japanese)
- Shima, T. et al. (1996). Research on the movement of throwing a flying disc, IV: Characteristics of the long distance throws of top athletes, Congress of the Japanese Society of Physical Education, 47, 555. (in Japanese)
- Shima, T. (2000). A Study on Systematic Coaching Method for Throwing Flying Disc, Studies in Physical Education (Sophia University), 33, 5-21. (in Japanese)
- Shima, T. (2002). Development of digital teaching materials for the flying disc, Congress of the Japanese Society of Physical Education, 53, 589 (in Japanese)
- Shima, T. (2004). A Study on How to Use Multimedia Teaching Materials in Flying Disc Class, Studies in Physical Education (Sophia University), 37, 33-58. (in Japanese)
- Soga, A., Myojin, Y. (2008). Educational Applications for Learning Rhythmic Gymnastics Rules Using Motion Data, Journal of Media Information and Television Engineering, 62(2), 222-226. (in Japanese)
- Takeuchi, M. (2010). Analysis of a side arm form in the flying disc throw using motion capture, Proceedings of the IEICE General Conference 2010, 2010IS(1), 63. (in Japanese)
- Yamaoka, K. et al. (2013). Capture and Feedback in Flying Disc Throw with use of Kinect, Int'l Journal of Sports Medicine and Sports Sciences, 74, 313-317.

Electroencephalogram Analysis of Pseudo-Haptic Application for Skill Learning Support System

Hirokazu MIURA^{a*}, Keijiro SAKAGAMI^b, Yuki SETO^b, Shumpei AKO^b
Hirokazu TAKI^{a*}, Noriyuki MATSUDA^{a*} & Masato SOGA^a

^a*Faculty of Systems Engineering, Wakayama University, Japan*

^b*Graduate School of Systems Engineering, Wakayama University, Japan*

* is-staff@sys.wakayama-u.ac.jp

Abstract: This paper describes the brain states analysis of pseudo-haptic application for the skill learning supporting system. The pseudo-haptic is a phenomenon in which the human perceives force by according differences between his/her real motion and its visual feedback. It is difficult to evaluate human cognition of haptic state only from the observation of human behavior. Therefore, to measure the biological signal of the brain, we have used electroencephalogram. We have evaluated the brain activity in the sensing tasks in order to make a comparison among the several states of the sensing of pseudo-haptic

Keywords: Pseudo-haptic, brain-machine interface, electroencephalogram, skill learning

1. Introduction

The learner would like to check his/her mastered skill level during his/her training. Therefore, it is necessary to feed back the current mastered skill level to the learner in the skill learning support system. The visual feedback is useful to check the skill level, and it has been used to present his/her motion and pose in the virtual reality (VR) system or the augmented reality (AR) system. When the learning support system teaches how much to make force or suggests the cautions of the skill by generating force in the skill behavior, the learner's force in his/her behavior must be able to be sensed. There are some Haptic Interfaces like as Phantom (Geomagic Touch, n.d.) and Spider (Sato, 2002) which have been used to generate force in these VR or AR systems. However these interfaces are expensive and used only in the laboratory.

While, there is a method how the learner feels haptic by a pseudo force generation device. We have felt that the mouse operation is heavier when its cursor moves slower than the user intention. This phenomenon is called "Pseudo-Haptic". When the operational object (cursor) moving speed is deferent from the simulated object behavior in the user's brain, the user feels the haptic as illusory perception (Crison, et al., 2004). The Pseudo-Haptic method is useful for the force feedback interface. The method is used easily and has cost advantage in order to generate haptic feedback. In the skill learning support system, the combination tool of the pseudo-haptic method and haptic devices as Phantom is able to teach complex force skill in the virtual space. However, it is difficult to evaluate the effect of pseudo-haptic for skill learning. Because the users feel the effect of visual force feedback subjectively, so there are individual differences of the effect of the learning system. Therefore, it is necessary to develop the evaluation method whether the learner recognize the pseudo-haptic and the learning support system's suggestion objectively.

2. Overview of Skill Learning Support System Using Pseudo-haptic

We have analyzed electroencephalogram of the learner who operates the device with pseudo-haptic phenomenon. We have tried to decide whether the learner feels haptic or not from electroencephalogram patterns. In the skill learning support systems, the visual feedback methods based on VR and AR are improved for the learners' self-recognition of their behaviors (Soga, M., Ishii, K.,

Nishino, T. and Taki, H., 2012). These systems make synthetic images from the learner's behaviors and the expert's ones in the virtual space. The learner watches the differences between his/her motion and the expert's one. However it is difficult to master the skill with force control from the virtual space which consists of motion and pose images. In the virtual space, the learner cannot feel the force of ball hitting in the baseball batting, playing tennis and so on. The pseudo-haptic makes sensing force like pressure in the virtual space by modifying motion images. So, we propose new system which uses pseudo-haptic (shown in Figure 1).

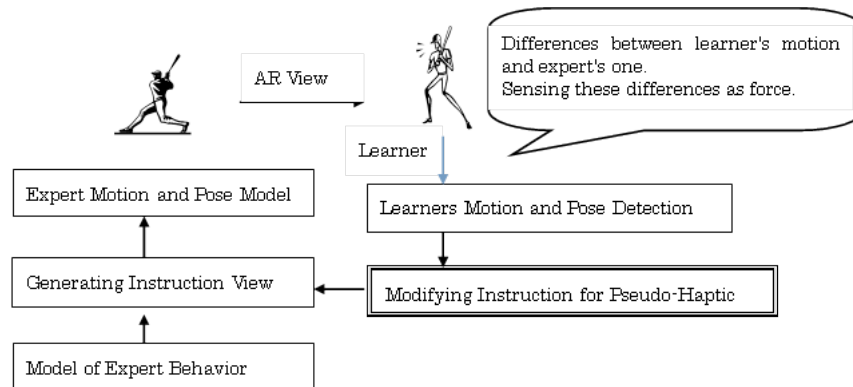


Figure 1. Skill Learning Environment.

2.1 Pseudo-haptic Phenomenon

The pseudo-haptic is a phenomenon of illusory perception which the human feel the haptic from the difference between his/her controlled mouse speed and the display its cursor speed. During the human is moving mouse in constant speed, the slower the cursor moves, the heavier he feels the weight of the mouse. The visual input of the mouse cursor behavior makes pseudo-haptic as if he/she feels reaction force against his/her hand (shown in Figure 2). This phenomenon is easy to generate, but the best ratio of input mouse speed and output cursor speed is calibrated before experiment.

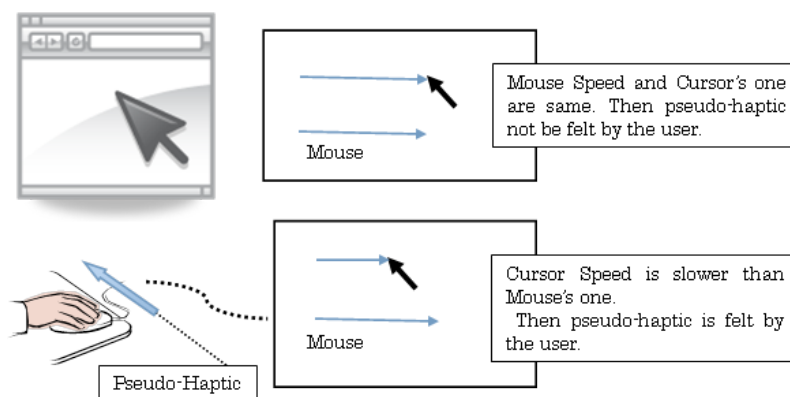


Figure 2. Pseudo-Haptic Generation.

3. Usage of Brain Machine Interface

3.1 Brain Machine Interface

The BMI (Brain Machine Interface) is an interface which measures the human brain electrical activity or cerebral blood flow. It is able to use for the direct communication tool between the human brain and the machine. There are an invasive measurement type BMI and a noninvasive measurement type BMI. In the invasive measurement type BMI, measuring probes are inserted into the human brain directly. It can measure the brain activity with high accuracy, but the problem of ethicality and safety exists. While, the noninvasive measurement type BMI measures the cerebral activity to use scalp contacting head attachments. It is easy to measure the brain activities, but it is affected by noise of the volume conductor

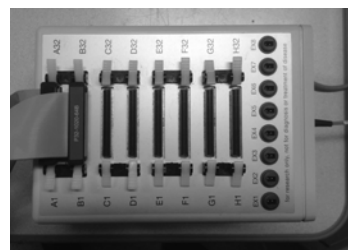
(skull and scalp) and the accuracy of data is lower than the invasive measurement type BMIs. Electroencephalogram (EEG) equipment is a kind of the noninvasive measurement type BMIs, and small size measure equipment. It has a high spatial resolution and is used most widely or frequently in a field of research. Our research also uses the EEG equipment to measure the cerebral activity when the learner works skillful learning tasks.

3.2 Electroencephalogram (EEG)

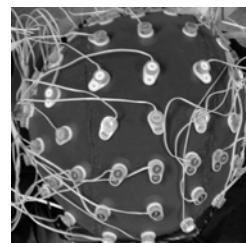
The minute signal electric current flows on the scalp in the several positions according to the cerebral activity connected with the brain. The EEG is a record which is measured neuron activities from some electric proves on the scalp. However, the minute signal electric voltage range is micro volt. It is difficult to measure the current, so the equipment amplifies this current by differential amplifier circuits which amplify a voltage of a difference between the signal of the reference point and the signal of the measuring point.

4. Brain Activity Measuring Experiment

We use the BioSemi Active Two system (Fig.3) to record EEG activity. The Active Two system has 64-channel proves and selects sampling rates which 2, 4, 8 or 16 kHz per channel. Instead of the mouse, we use the Sensable Technologies PHANTOM Omni (Fig.4) as cursor input device. We use the PHANTOM which does not generate any forces.



(a) ActiveTwo AD-box.



(b) Electrodes in ActiveTwo

Figure 3. BioSemi ActiveTwo System.



Figure 4. Phantom Omni (Geomagic Touch).

4.1 Experiment

We have measured the following conditions:
The cursor has moved in normal and slow speed.

Task 1. PHANTOM stylus speed : Cursor speed in the display = 100 : 75

Task 2. PHANTOM stylus speed : Cursor speed in the display = 100 : 50

The subjects are 3 young men in their twenties.

Test Task: the subject traced the sphere as mark by the PHANTOM stylus. This sphere's speed is 6cm per second and it reciprocates in the horizontal direction. One trial consists of these 2 tasks. One test set

consists of 5 trials. The sequence of one task is 4 seconds rest, 7 seconds task and 4 seconds rest (Fig.5 and Fig.6).



Figure 5. Experiment Image.



Figure 6. Test Sequence.

4.2 EEG Analysis

This section describes EEG analysis (Obana, H., et al., 2013)(Seto, Y., Ako, S., Kashu, T. et al., 2013)(Seto, Y., Ako, S., Miura, H. et al., 2013). We have selected alpha-wave and beta-wave range data by the band pass filter (8-30 Hz) to eliminate noise (Table 1). To acquire the frequency distribution specification of the wave data, we have used FFT (Fast Fourier Transform).

Table 1: EEG frequency.

wave	δ	Θ	α	β	γ
Hz	1-3	4-7	8-13	13-30	30-
State	Deep Sleep	Shallow Sleep	Relax	Normal	Excite

We have normalized data of the frequency distribution power spectrum in order to eliminate the gain change effects.

$$f(x) = \frac{x - x_{min}}{x_{Max} - x_{min}} \quad \dots\dots\dots(1)$$

X_{max} : maximum of the power spectrum
 X_{min} : minimum of the power spectrum

A frequency which has a maximum characteristic value is the first principle. Main component scores are determined from characteristic vectors and frequency distribution power spectrum by the principal component analysis.

$$y_k = w_{k1}x_1 + w_{k2}x_2 + \dots + w_{kn}x_n \quad \dots(2)$$

y_k : k-th main component score

w_k : k-th characteristic vector

x : frequency distribution power spectrum

4.3 Discrimination by Neural Networks

We have used the three layers neural networks (Fig.7) to discriminate signals which electrodes are detected when the learner feels pseudo-haptic. This neural networks selects electrodes based on main component scores.

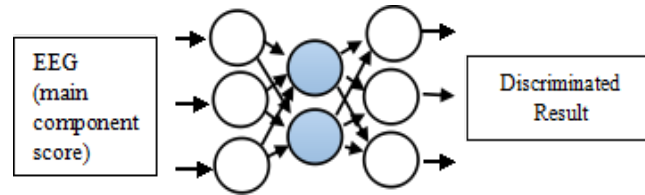


Figure 7. Neural Networks.

5. Results

We have analyzed the EEG data by normalization and FFT PCA. We have selected frequencies which has the main component scores corresponding to the cumulative contribution ratio that exceeds a prescribed value (80%). The neural networks was trained by items of these main component scores of odd number measured data. When the even number measured data "Task 1" is inputted into the neural networks, it selected electrodes AF4, CPz, F2, F7, FC6,P1,P3,P4,P5,P6,P7,P8,P03,T7,T8,TP7,TP8 are selected (Fig.8 and Table 2). When the even number measured data "Task 2" is inputted into the neural networks, it could not select electrodes.

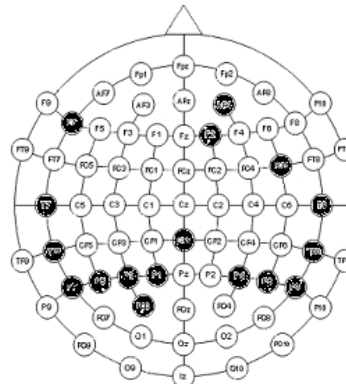


Figure 8. Important Electrodes.

Table 2: Identification rate.

Electrode	Subject1	Subject2	Subject3
AF4	61.5%	92.3%	69.2%
CPz	76.9%	69.2%	69.2%
F2	69.2%	76.9%	69.2%
F7	69.2%	69.2%	84.6%
FC6	76.9%	69.2%	69.2%
P1	84.6%	76.9%	69.2%
P3	84.6%	69.2%	69.2%
P4	84.6%	76.9%	53.8%
P5	76.9%	76.9%	69.2%
P6	69.2%	76.9%	69.2%
P7	76.9%	76.9%	61.5%
P8	61.5%	76.9%	69.2%
P03	76.9%	76.9%	53.8%
T7	76.9%	92.3%	84.6%

T8	69.2%	61.5%	76.9%
TP7	76.9%	92.3%	61.5%
TP8	84.6%	69.2%	69.2%

6. Consideration

We have selected the important electrodes to be able to detect pseudo-haptic. These electrodes are in temporal area, temporal-posterior temporal area, posterior temporal area. The group of areas is temporal association area which processes visual perception and auditory perception to recognize information from visual cortex and auditory cortex. The parietal area data is useful to discriminate which the learner feels the pseudo-haptic. This area is related to physical sensation perception and visual perception of space. So this area recognizes what the learner watches from visual information. The pseudo-haptic is an illusory perception of visual information. Therefore the brain area of visual information processing is activated when the learner feels pseudo-haptic.

7. Summary

We have studied the EEG data that the learner feels pseudo-haptic. The data have been analyzed by normalization and FFT PCA and discriminated by the neural networks. We have selected the important electrodes to detect pseudo-haptic perception. The system can recognize which the learner feels the pseudo-haptic or not from the EEG patterns. Therefore, we can evaluate the advantage of the pseudo-haptic phenomena for skill learning.

In the future work, we will try to use this pseudo-haptic for skill learning.

Acknowledgements

The research is supported by the original research project found of Wakayama University.

References

- Geomagic Touch. (n.d.). Retrieved Sep. 1, 2013, from <http://geomagic.com/en/products/phantom-omni/overview>
- Sato, M. (2002). *Development of string-based force display: Spidar. Proceedings of the 8th International Conference on Virtual Systems and Multi Media (VSMM 2002)*,
- Crison, F., Lécuyer, A., Savary, A., Mellet-D'Huart, D., Burkhardt, J.M., and Dautin, J. (2004). *The use of haptic and pseudo-haptic feedback for the technical training of milling. Proceedings of the EuroHaptics Conference*.
- Soga, M., Ishii, K., Nishino, T., Taki, H. (2012). *A New Method for Non-Dominant Motion Skill Learning by Using Motion Navigator. Proceedings of KES2012*, 953-959.
- Obana, H., Ako, S., Kashu, T., Sakagami, T., Seto, Y., Miura, H., Mastuda, N., and Taki, H. (2013). *Classification of Haptic Tasks based on frequency analysis of EEG. The Papers of Technical Meeting on Innovative Industrial System, IEE Japan, IIS-13-035*. (in Japanese)
- Seto, Y., Ako, S., Kashu, T., Sakagami, T., Obana, H., Miura, H., Matsuda, N., Taki, H.. (2013). *Analysis of brain state in the decision-making by using EEG. The Papers of Technical Meeting on Innovative Industrial System, IEE Japan, IIS-13, 25-28*. (in Japanese)
- Seto, Y., Ako, S., Miura, H., Matsuda, N., Taki, H. (2013). *Analysis of brain state in imaging directions by using EEG, The 35th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC'13)*.

Exploring Educational Transformation through ICT in Emerging Developing Countries within the Asia-Pacific Region

Su Luan WONG^{a*}, Ahmad Fauzi Mohd AYUB^b, Mohammad LUKMAN^c & Chien-Sing LEE^d

Organizers of WICTTEE 2013^{a,b,c,d}

Faculty of Educational Studies, Universiti Putra Malaysia, Malaysia^{a,b}

University of Muhammadiyah Prof. Dr. Hamka, Indonesia^c

Faculty of Creative Industries, Universiti Tunku Abdul Rahman, Malaysia^d

**suluan@upm.edu.my*

Governments in emerging developing countries have started to take incremental but concrete steps to leverage on the potential of ICT to transform education at all levels in their respective countries (Southeast Asian Ministers of Education Organization, 2010). Many countries have started allocating an appropriate amount of their yearly budget for ICT development in education. Indeed, this is a bold step to bridge the gap between education and economy. No doubt, education policy makers are “attracted to the prospect that ICT can improve student achievement, improve access to schooling, increase efficiencies and reduce costs, enhance students’ ability to learn and promote their lifelong learning, and prepare them for a globally competitive workforce” (Kozma, 2011, p. 4).

Often, the educational transformation through ICT is full of challenges and can sometimes be messy. On one hand these challenges can be unique to each country and on the other hand be common among the emerging developing countries. Obviously, there is much to explore and learn about the transformation that is taking place in these countries’ education system. In response to the growing research diversity among emerging developing nations within the Asia-Pacific region, the Second International Workshop on ICT Trends in Emerging Economies (WICTTEE 2013) is held in conjunction with the 21st International Conference on Computers in Education, Bali, Indonesia. WICTTEE 2013 is organized by the SIG on Development of Information and Communication Technology in the Asia Pacific Neighbourhood—DICTAP. The visions of DICTAP are to:

1. Share ideas and best implementation practices related to government policies and incentives aimed at promoting human resource development, technology transfer, effective e-learning strategies and implementation, software and content development suitable for each member of the Asia-Pacific neighborhood;
2. Coordinate and promote community-based e-learning activities, global sharing and management of information and knowledge. Examples of such communities are the Asia-Pacific Society on Computers in Education (APSCE) and the Association of South East Asian Nations (ASEAN); and
3. Coordinate and promote student and staff exchange among Asia-Pacific neighborhood member nations to promote more effective sharing of knowledge and practices.

The missions of DICTAP are to:

1. Connect researchers from emerging developing countries within the Asia-Pacific region to share scholarly findings and professional insights in ICT development in the field of education;
2. Establish networking opportunities among researchers, reduce the research gap between the researchers from more developed and less developed countries; and
3. Foster, enhance and sustain collaborations among these researchers.

WICTTEE 2013 is the second workshop that we are organizing in the hope to realise the aforementioned visions and missions. The workshop is a continuation of our relentless effort to

provide a dynamic platform for practitioners and researchers alike to come together to share their country experiences.

We are extremely pleased that practitioners and scholars with university affiliations from China, Malaysia, and Indonesia will be congregating in Bali, Indonesia to present their research findings and share their views at WICTTEE 2013. A total of seven papers will be presented in a full day workshop.

We would like to take this opportunity to thank all the authors who submitted their papers to WICTTEE 2013. We would like to record our sincerest appreciation to our Program Committee Members who dedicated their time and expertise to the most challenging and demanding task of reviewing the paper submissions. Last but not least, we would like to thank DICTAP's Advisory Committee Members for their wisdom and guidance in making WICTTEE 2013 a reality.

References

- Kozma, R.B. (2011). The Technological, Economic, and Social Contexts for Educational ICT Policy. In *Transforming Education: The Power of ICT Policies*. Paris: UNESCO.
- Southeast Asian Ministers of Education Organization (2010). *Report of the Status of ICT integration in Education in South East Asian countries*. Accessed 5 October 2012, http://www.icde.org/filestore/Resources/Reports/SEAMEO_ICT-Integration-Education2010.pdf

Do Teacher Related Factors Play a Role in Laptop Use for Teaching-Learning?

Su Luan WONG^{a*} & Priscilla Moses^b

^a*Faculty of Educational Studies, Universiti Putra Malaysia, Malaysia*
Faculty of Arts and Social Science, Universiti Tunku Abdul Rahman, Malaysia

*suluan@upm.edu.my

Abstract: Equipping laptops to Malaysian teachers is a much needed step to advance the education system. Central to this, teachers must be recognized as the change agent in the successful use of laptops and ICT innovation in schools. This study was conducted to explore the overall profile of teachers' laptop use and also to investigate if selected teacher related factors (age, gender, teaching experience, laptop experience, attitudes towards laptop use and laptop skills) play a role in laptop use for teaching-learning. A total of 463 teachers participated in this study and the findings indicate that teachers are not using laptops as much as they should in the classrooms. The findings also suggest that four teacher related factors (gender, laptop experience, attitudes towards laptop use and laptop skills) play a significant role in teachers' laptop use for teaching-learning.

Keywords: laptop use for teaching-learning, age, gender, teaching experience, laptop experience, attitudes towards laptop use, laptop skills

1. Introduction

In many countries, the respective governments have taken concrete steps to improve the teaching and learning environment by incorporating technology in the curricula. There have been moves to promote teachers' use of technology and thus, laptop initiatives have been introduced. Consistent with other countries, Malaysia also began the laptop initiative in 2003 by providing each Mathematics and Science teacher with a laptop. Moreover, to advance the wider use of technology in education, the Malaysian government is pursuing every effort to create an encouraging and ongoing ICT environment to improve laptop use among the teachers in schools. The laptop scheme is a significant move to take full advantage of technology in the teaching and learning processes.

Teachers undeniably play a crucial role in integrating ICT into their instructional practices via the laptop initiatives. In any teaching-learning environments, teacher related factors are seen to be one of the most powerful predictors of successful integration or use of ICT (Sang, Valcke, van Braak, Tondeur & Zhu, 2010). In other words, teachers play an important role in the success of ICT use in teaching and learning.

2. Related Studies

Laptop Use among Teachers

Within the Malaysian context, the findings from a small scale study conducted by Moses, Wong, Bakar & Mahmud (2012) among 38 Maths and Science teachers from one state suggested that teachers used the laptop moderately for lesson preparation and classroom instruction despite being equipped with laptops in schools. At the same time Khambari et al. (2012) conducted a similar study, albeit on a bigger scale, in another state to gauge the impact of laptops on 386 Maths and Science teachers. Their findings indicate that equipping these teachers with laptops have a moderate impact on their laptop use for teaching-learning. The researchers from both studies believed that the teachers are using laptops moderately because they are still trying to adapt to the learning environment and thus need more time to familiarise themselves with the laptops (Moses et al., 2012; Khambari et al., 2012).

Teacher Related Variables

Rahimi and Yadollahi (2011) stressed that teacher characteristics should not be overlooked when investigating factors contributing to ICT use. In this respect, past studies have suggested that teaching experience is linked to ICT integration or use. Van Braak, Tondeur and Valcke (2004) and Rahimi and Yadollahi (2011) found that there was an inverse relationship between teaching experience and computer use for teaching-learning. They postulated that those with more teaching experience are usually older teachers who shun technology use in classrooms. Denson (2005), however, concluded that there was no relationship between teachers' years of experience in the classroom and teachers' perceived levels of technology integration in the classroom. Braak et al. (2004) reported that there was an inverse significant relationship between age and supportive computer use which refers to the use of computers for pro-active and administrative tasks. At the same time, they also reported that the relationship between teachers' class use of computers and age could be ignored. On further investigation, they found that when controlled for computer experience, intensity of computer use and computer attitudes, age has no significant effect on support computer use. Cutler, Hendricks and Guyer (2003) added that the effects of age on computer use may be eliminated when key compositional factors such as gender, education, income, size of household, disabilities, employment and marital status, and race are controlled. It is also widely believed that the more teachers are familiar with computers, the higher their reported level of ICT use. Recently, Bakar, Wong, Wong and Hamzah (2013) also provided evidence that teachers who use computers for teaching-learning are those with more computer experience and are frequent computer users.

An earlier study by Zhao, Pugh, Sheldon and Byers (2002), revealed that, teachers do not always have the knowledge and skills to meaningfully integrate technology into their classes. For computer technology to be successful in schools, teachers need to be trained and well prepared to competently integrate it into their curricular. Khan, Hasan and Clement (2012) agreed that one of the reasons for the low level of ICT integration in schools was because teachers were not proficient in the use of technology. Teachers' attitudes towards ICT can be considered to be another major obstacle to technology integration (Hermans, Tondeur, Valcke, & Van Braak, 2006). Teachers' attitudes have been found to have a direct influence in their intention to use technology (Luan & Teo, 2009). Braak et al. (2004) suggested that teachers with more positive computer attitudes used computers in the classroom to a greater extent. Sang et al. (2010) observed that attitudes towards ICT use in education influence ICT classroom integration through mediation of ICT motivation and ICT supportive use. In other words, "if primary teachers adopt favorable attitudes towards ICT in education, they are more eager to integrate ICT into their teaching" (Sang et al., 2010; p.11). Interestingly, in an older study, Ryan, Szechtmann and Bodkin (1992) asserted that older individuals possess less favourable attitudes towards ICT and thus have lesser propensity to use it when it is available. This means that technology use declines with age but Cutler et al. (2003) cautioned that age differences in technology use are less apparent when compositional variability such as employment status, marital status, education and others are taken in account.

The effects of gender on technology use have also been widely studied. The issue of gender gap exists for technology use (Moses, Khambari & Luan, 2008; van Braak et al., 2004). The findings by Markauskaite (2006) indicated that male graduate trainee teachers use computers to a greater extent than females do. Male teachers also use computers more often than their female counterparts (van Braak et al., 2004). van Braak et al. (2004) concluded that there is a significant gender effect on supportive and class use. On the contrary, Wong, Bakar, Wong and Hamzah (2012) found no gender differences between male and female school teachers in terms of technology use for instructional purposes. They explained that this could be due to the expectations placed on teachers and also ICT use has become essential in Malaysian teachers' professional and daily lives.

3. Purpose of the Study

The literature suggests that the success of ICT use depends partly on teacher factors such as their age, gender, teaching experience, laptop experience, attitudes towards laptop use and laptop skills. In this respect, the main purpose of this study is to explore whether the aforementioned factors play a role in teachers' laptop use for teaching-learning. It is, therefore, critical to investigate this link given that the MMOE places strong emphasises on laptops as an effective tool to promote learning. Based on the aforesaid purpose, the research questions will be answered:

1. What is the overall profile of teachers' laptop use?
2. Is there a relationship between teacher related factors (age, laptop experience, laptop skills, attitudes towards laptop use and teaching experience) and laptop use?
3. Does laptop use differ by gender?

4. Methodology

Participants

The participants were 463 randomly selected secondary school teachers in Malaysia from three states. There were more female teachers (86.2%) than males (13.8%). In terms of their academic qualifications, 44 (9.5%) of the teachers held a masters degree, 414 (89.4%) held a bachelor degree, 3 (0.6%) respondents were at the diploma level and lastly 2 (0.4%) held a teaching certificate. Their overall mean for years of teaching experience and laptop experience was 11.63 years (S.D. = 8.25) and 4.95 years (S.D.=2.49) respectively. Their mean age was 37.09 years old (S.D.=8.81).

Instrumentation

The instrument used in this study captured information about the respondent's age, teaching experience, laptop experience, laptop skills, attitudes towards laptop use and laptop use for teaching-learning. Laptop skills was measured in terms of two dimensions—1. Basic Laptop Operation Skills and Setup, and 2. Maintenance and Troubleshooting of Laptop. Items were measured using a four point scale: "Not able to perform the task", "Able to perform the task with some assistance", "Able to perform the task without assistance" and "Able to teach others how to perform the task".

Items measuring attitudes towards laptop use were adapted from Albirini (2006). Each item in this scale used a five-point Likert-type. Based on this scale, the respondents rated their attitude towards laptop use on each item, from strongly "disagree" to "strongly agree".

Laptop use for teaching-learning was measured by the regularity of the current laptop usage in class as perceived by the teachers. The five-point Likert scale was used for these items so as to measure the frequency of laptop use. The items were rated by the respondent as "Never", "Once in a while", "Sometimes", "Often" or "Very Often"

5. Results

Teachers' Laptop Use for Teaching-Learning

Table 1 presents the teachers' responses in regard to their laptop use for teaching-learning as measured by 11 items. The mean scores for all items were not more than 4.0. This suggests that teachers do not use the laptops very often for classroom teaching. The information in the table also suggests that there are teachers who do not use the laptops in classrooms at all. Despite this worrying trend, Table 1 shows that about one third of the teachers use the laptop sometimes or often for teaching-learning. In other words, teachers are already incorporating laptops as a teaching-learning tool and using them for assessment in the classrooms.

Table 1: Descriptive Statistics of Laptop Use for Teaching-Learning

Item	Never	Once in a while	Sometimes	Often	Very often	M	S.D.
	f	f	f	f	f		
	(%)	(%)	(%)	(%)	(%)		
I use the laptop in the teaching and learning process.	0 0	113 24.4	133 28.7	133 28.7	84 18.1	3.41	1.05
I use the laptop to aid the usage of CD-ROM during the teaching and learning process.	29 6.3	102 22	141 30.5	132 28.5	59 12.7	3.19	1.11

I use the laptop to facilitate the various pedagogical approaches (e.g.: collaborative learning, problem-based learning etc.).	46 9.9	90 19.4	140 30.2	139 30	48 10.4	3.11	1.14
I use the laptop as a tool for multimedia presentation during the teaching and learning process.	42 9.1	95 20.5	122 26.3	139 30	65 14	3.19	1.18
I use the laptop to provide detailed explanations (e.g.: visual aids etc.) during the teaching and learning process.	37 8.0	100 21.6	120 25.9	130 28.1	76 16.4	3.23	1.19
I use the laptop in class to provide notes to the students.	89 19.2	100 21.6	133 28.7	88 19.0	53 11.4	2.82	1.27
I use the laptop to show examples (e.g.: pictures, animation, audio, video etc.) to enhance the students' learning.	31 6.7	86 18.6	129 27.9	137 29.6	80 17.3	3.32	1.16
I use the laptop to facilitate the use of relevant Internet resources during the teaching and learning process.	109 23.5	110 23.8	128 27.6	80 17.3	36 7.8	2.62	1.23
I use the laptop to carry out classroom activities.	82 17.7	127 27.4	144 31.1	78 16.8	32 6.9	2.68	1.15
I use the laptop to carry out assessments in class.	125 27.0	132 28.5	117 25.3	69 14.9	20 4.3	2.41	1.16
I create a conducive learning environment (e.g.: educational flash, jokes, music etc.) using the laptop to motivate the students to learn.	90 19.4	139 30.0	125 27.0	82 17.7	27 5.8	2.60	1.16

Relationship between teacher related factors and laptop use

Table 2 shows the correlation between laptop use for teaching-learning and the five teacher related factors— age, laptop experience, laptop skills, attitudes towards laptop use and teaching experience. The relationships were explored using the Pearson product-moment correlation coefficient. Preliminary analyses were performed to ensure no violation of the assumptions of normality, linearity and homoscedasticity. The rule of thumb by Sprinthall (1994) was used for interpreting the results of the r values in this study. The results revealed that laptop use was inversely and significantly correlated with age ($p < 0.05$). Laptop use was also inversely but not significantly correlated with teaching experience. However, the strength of the associations between laptop use and both these factors can be considered as negligible. The results also showed that laptop use was positively and even more significantly correlated with laptop experience ($p < 0.01$), laptop skills ($p < 0.01$) and attitudes towards laptop use ($p < 0.01$). However, it can be considered that a small but definite relationships existed between laptop use and laptop experience as the Pearson r correlation was close to .20. Substantial relationships existed between laptop use and the two remaining factors—laptop skills and attitudes towards laptop use.

Table 2: Correlation between Laptop Use and Teacher Related Variables

Variable	1	2	3	4	5	6
1. Laptop use	1.00					
2. Age	-.10*	1.00				
3. Teaching experience (years)	-.08	.91**	1.00			
4. Laptop experience (years)	.18**	.43**	.42**	1.00		
5. Laptop skills	.39**	-.30**	-.26**	.03	1.00	
6. Attitudes towards laptop use	.60**	-.13**	-.12**	.13**	.55*	1.00

*Correlation is significant at the .05 level (2- tailed)

**Correlation is significant at the .01 level (2- tailed)

Effects of Gender on Laptop Use for Teaching-Learning

The independent samples t-test was used to determine if there were differences in terms of gender for laptop use. The independent samples t-test analysis showed a significant difference in the laptop use for teaching-learning scores between females ($M=32.08$, $S.D.=10.44$) and males [$M=35.83$, $S.D.=11.17$; $t(461) = 2.64$, $p = .009$]. The effect size was small ($\eta^2 = .01$).

6. Discussion

The first research question explored the teachers' laptop use for teaching-learning. The findings suggest that teachers are using laptops in the classroom but not at a very encouraging rate despite having access to such facilities in schools. This is quite worrying because the laptop initiative was launched more than a decade ago. The finding of this study was similar to Moses et al. (2012) and Khambari et al.(2012) who reported that teachers' laptop use was at the moderate level only.

According to Khambari et al. (2012) some teachers find it difficult to embrace new technology because they are used to the traditional method of teaching in the classrooms. Likewise teachers may find it difficult to be updated with the latest ICT trends and lack time to explore the affordances of laptops as an instructional tool (Urwin, 2007). However, from a more optimistic point of view, the findings provide some evidence that teachers are making some efforts to embrace laptops as a teaching-learning tool and move away from the conventional method of teaching.

The second research question concerned the relationship between five teacher related variables and laptop use for teaching-learning. The present study ascertained that three teacher related variables (laptop experience, attitudes towards laptop use and laptop skills) are quite strongly and positively correlated with laptop. In other words, teachers with more laptop experience would use laptops in their teaching-learning to a greater extent. Teachers with more positive attitudes towards laptop use and who were proficient with the laptops tended to use them more in the classrooms. Findings of the current study showed parallelism with the findings of Braak et al. (2004) that suggested teachers' experience with technology was positively related to the use of technologies in classroom. The findings of the present study are also congruent with past studies (Khan et al., 2012) that provided evidence supporting ICT skill as a key factor in ICT integration. The inverse association of the remaining teacher variables (age and teaching experience) with laptop use was negligible. This finding contrasted with van Braak et al. (2004) and Rahimi and Yadollahi (2011). The negligible relationship between age and laptop use for teaching-learning could be due to the similar compositional characteristics that the majority of the teachers in the present study share such as their teaching qualification, employment with the Ministry of Education and moderate income level.

The last research question concerned the effects of gender on teachers' laptop use for teaching-learning. This study found laptop use for teaching-learning was dependent on gender. Male teachers used the laptops to a greater extent than female teachers did. This findings supports past research which suggested significant differences in technology use by gender (van Braak et al., 2004; Markauskaite, 2006) but contradicted Wong et al. (2012). Shapka and Ferrari (2003, p. 416) explained that gender differences may still exist when teachers are less familiar in the use of computer applications. For this reason, the authors can only conjecture at this point that male teachers are more comfortable and familiar with laptops than female teachers and this gives them the edge in laptop use during class hours.

7. Conclusion

The introduction of laptops as a teaching-learning tool in Malaysian classrooms is the right step forward to transform the learning environment and empower teachers. The investment on laptops must continue to push Malaysia to be at par with more developed countries. The MMOE is serious in their effort to strive for excellence in the education system through ICT. Central to this, teachers must be recognized as the change agent in the successful use of laptops and ICT innovation in schools. For this reason, it is important to learn more about the teacher related factors and their link with laptop use for teaching-learning. This study suggests that more needs to be done by the MMOE to promote teachers' laptop use for teaching-learning. It also provides some evidence that teacher related factors such as their laptop experience, laptop skills and attitudes towards laptop use and gender should not be ignored when steps are taken to enhance and sustain effective laptop use among Malaysian teachers.

Acknowledgements

This paper is based on a PhD thesis completed by the second author under the supervision of the first author.

References

- Albirini, A. (2006). Teachers' attitudes toward information and communication technologies: the case of Syrian EFL teachers. *Computers & Education*, 47(4), 373-398.
- Bakar, A.R., Wong, A.B., Wong, S.L. & Hamzah, R. (2013). What Factors Lead Teachers to Integrate Information and Communication Technology in Classroom Teaching?. In R. McBride & M. Searson

- (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2013* (pp. 3020-3026). Chesapeake, VA: AACE.
- Cutler, S.J., Hendricks, J. & Guyer, A. (2003). Age differences in home computer availability and use. *Journal of Gerontology*, 58B(5), 271-280.
- Denson, B. (2005). Teacher attitudes toward technology. Doctoral Dissertation, Tennessee State University. (ERIC Document Reproduction Service No: 3167774).
- Hermans, R., Tondeur, J., Valcke, M. M., & van Braak, J. (2006). Educational beliefs as pre-dictors of ICT use in the classroom. Paper presented at the convention of the American Educational Research Association, San Francisco, CA.
- Khambari, M.N.M., Luan, W.S. & Mohd Ayub, M.F. (2012). Promoting teachers' technology professional development through laptops. *Pertanika Journal of Social Sciences*, 20(1), 137-145.
- Khan, M. S. H., Hasan, M., & Clement, C. K. (2012). Barriers to the Introduction of ICT into Education in Developing Countries: The Example of Bangladesh. *International Journal of Instruction*, 5(2), 61–80.
- Luan, W. S., & Teo, T. (2009). Investigating the technology acceptance among student teachers in Malaysia: an application of the technology acceptance model (TAM). *Asia-Pacific Education Researcher*, 18(2), 261–272.
- Markauskaite, L. (2006). Gender issues in preservice teachers' training: ICT literacy and online learning. *Australasian Journal of Educational Technology*, 22(1), 1-20.
- Moses, P., Khambari, M.N.M. & Luan, W.S. (2008). Laptop use and its antecedents among educators: A review of the literature. *European Journal of Social Sciences*. 7(1), 104-114.
- Moses, P., Wong, S.L., Bakar, K.A. & Mahmud, R. (2012). Exploring the relationship between attitude towards laptop usage and laptop utilisation: A preliminary study among Malaysian Science and Mathematics teachers. *Pertanika Journal of Social Sciences*, 20(3), 847-864.
- Rahimi, M., & Yadollahi, S. (2011). ICT Use in EFL classes: a focus on EFL teachers' characteristics. [Report]. *World Journal of English Language*, 1(2), 17-29.
- Ryan, E. B., Szechtmann, B., & Bodkin, J. (1992). Attitudes toward younger and older adults learning to use computers. *Journal of Gerontology: Psychological Sciences*, 47, 96–101.
- Sang, G.Y., Valcke, M., Van Braak, J., Tondeur, J., & Zhu, C. (2010). Factors associated with the integration of ICT into Chinese primary school classrooms: interplay of teacher- related variables. *Language Education and Technology*, 40, 30-45.
- Shapka, J.D. & Ferrari, M. (2003). Computer-related attitudes and actions of teacher candidates. *Computers in Human Behavior*, 19(3), 319-334.
- Sprinthall, R.C. (1994) *Statistical Analysis*, 4th ed., Allyn and Bacon, Massachusetts.
- Urwin, A. (2007). The Professionalism of the Higher Education Teacher: What's ICT Got to Do with It? *Teaching in Higher Education*, 12(3), 295-308.
- van Braak, J., Tondeur, J., & Valcke, M. (2004). Explaining different types of computer use among primary school teachers. *European Journal of Psychology of Education*, 19(4), 407-422.
- Wong, A.B., Bakar, A.R. Bakar, Hamzah, R. & Wong, S.L. (2012). ICT Integration in Malaysian Smart Schools: Do teachers' gender, computer ownership, Internet access, subject area and ICT training matter? In Chang, B. et al. (Eds). *Workshop proceedings of the 20th International Conference on Computers in Education*. Asia Pacific Society of Computers in Education. pp. 80-169
- Zhao, Y., Pugh, K., Sheldon, S., & Byers, J. L. (2002). Conditions for classroom technology innovations. *Teachers College Record*, 104(3), 482-515.

Classroom Action Research: Using Interactive Learning Media to Improve Students' Colligative Solution Learning Outcome.

Yusnidar YUSUF^{a*}, Endy Syaiful ALIM^{a**}, Tyas Hermala ANINDITA^{a***}

^aUniversity of Muhammadiyah Prof. DR. HAMKA (UHAMKA), Indonesia

*yusnidar_yusuf@yahoo.co.id

**esaitb@yahoo.com

***ty_as15@hotmail.com

Abstract: This research aims to increase the ability of students to understand and improve their learning outcome when studying the subject of colligative solutions in chemistry. It also hopes to improve the ability of teachers to deliver the subject. This research was conducted at SMA Negeri IX Jakarta to the twelfth grade. It was a classroom action research carried out in five months comprising of two cycles. It involved two observers in the school. Based on the result, there is a significant increase of students' test grades from cycle 1 to cycle 2, which is from 76.5 to 79.7. From the students' learning effectiveness records, it is suggested that learning with interactive learning media can successfully improve students' learning outcome, especially in the subject of colligative solution in Chemistry.

Keywords: software, interactive learning media, chemistry, colligative, solution

1. Introduction

Education Unit Level Curriculum (EULC), which is an operational curriculum that is developed and implemented by each educational unit, currently require teachers to develop and compile suitable teaching and learning materials based on the curriculum.

In learning chemistry, many obstacles are faced by the students as well as the teachers in terms of learning materials availability. These include the limitation of equipment and materials, understanding the theoretical and microscopic concept, and the dangerous experiments due to the content of the physical and chemical properties of the experimental products.

The role of learning model, strategy and methodology used by the teacher in explaining the learning materials to the students greatly affect their interest and motivation in understanding the concept of chemistry. As in this case, it is important for a teacher to prepare, plan, deliver, and evaluate materials so that students will like the subject. To a large extent, this is dependent upon the presentation of the materials given by the teacher.

Learning process should pay attention to the students' individual conditions because they are the ones who are doing the learning. Students are unique individuals. Therefore, education should pay attention to the differences in individual, so that learning can effectively change the condition of students from not knowing to knowing, from not understanding to understanding, from unskilled to skilled, and from less behaved to well-behaved.

One of the topics needed to be explained in the chemistry syllabus is the colligative properties of solution. In chemistry, a solution is a homogenous mixture that consists of two or more substances. A substance that has lower quantity inside a solution is called a solute, while a substance in which the quantity is more than all the other substances in a solution is called a solvent. The composition of solute and solvent in a solution is expressed in the *concentration* of solution, while the mixing process of solute and solvent to form a solution is called *dissolution* or *solvation*.

This theoretical description of the colligative properties of solution is difficult for children to understand because imagination is needed to understand the concept. Therefore, there need to be alternative methods to help the children. One of them is the interactive learning method based on computer or ICT. The choice of interactive multimedia learning method is expected to increase the learning outcome of students. Therefore, this study was carried out in order to know if there is an increase in students' learning outcome of the colligative properties of solution.

2. Theoretical Background

Learning is the main activity in the process of education in schools. This means that the success or failure in the achievement of educational goals largely depends on the learning process experienced by the students. Therefore, every teacher should understand the learning process of their students well and the pedagogy used to present the teaching materials so that teachers can give guidance and provide a proper and harmonious learning environment for the students.

2.1. Learning with Interactive Multimedia

According to Von Glasersfeld (1989), education is helping someone to think correctly by letting them think for themselves. Good thinking is more important than having a good way of thinking. Students who could give correct answers may not necessarily be able to solve new problems, possibly because they do not understand how to find the answer. Learning is not an activity to transfer knowledge from teacher to student, but an activity that allows students to build their own knowledge. It is a form of independent activity. Interactive multimedia is a media that consists of teaching materials loaded with programming language. The more commonly used include **power point** and **flash**. Interactive multimedia has several types:

- a. Drill dan Practice
It gives instructions through drill and opportunity to measure ability through test. This type is usually used to increase basic knowledge.
- b. Tutorial
Computer replaces teacher or tutor. It presents information, asks questions and gives responses (feedback).
- c. Simulation
Simulation type is used to present or imitate real situations.
- d. Games
This is suitable to train users to make fast decisions when solving problems especially in competition, challenge, strategy setting and others.

2.2. Classroom Action Research

Classroom Action Research (CAR) is a study which is based in the classroom. It is implemented by teachers in order to solve learning problems faced by them. These include either fixing the quality and study results, trying new learning method for the sake of quality, or simply to improve results. According to Zulfikri (2010), based on the quantity and behavioural traits of the members, CAR can be in the form of individual or collaborative, which is known as individual CAR and collaborative CAR. In individual CAR, the teachers conduct CAR in their own or other classes, while in collaborative CAR, several teachers will be conducting CAR at the same time in their own classes or between members exchanging classrooms' visits.

CAR has a number of characteristics as the following:

- a. Cyclical, which means that CAR uses cycles (planning, give action, observation, and reflection), as concrete research procedure.
- b. Longitudinal, which means that CAR should take place in a certain time frame (for example 2-3 months) and continuously obtaining the required data. It is not finished in "one shot".
- c. Particular-specific, so it does not intend to generalise in order to obtain theories. The results are not for generalisation, although perhaps can be replicated by other researchers in similar context.
- d. Participatory means teacher as the researcher, as well as the object of change who has problem to be solved. This requires the teacher to play double roles.
- e. *Emik* (not *etik*), which means that CAR views learning from the people inside which are near to the object of research and it is not based on the point of view of the people outside who are far from the object of research.
- f. Collaborative or Cooperative, which means that a collaboration or working together between the researchers (teacher) and other parties always occur within the conduct of CAR to ensure validity and achievement of research objectives.

- g. Casuistic, which means that CAR works on specific or particular cases in learning which are real and affordable by the teacher; working on big problems.
- h. Uses natural classroom context, which means that class as the area of implementation of CAR do not need to be manipulated and/or engineered for the needs, importance, and the achievement of research objectives.
- i. Prioritize the sufficiency of data needed to achieve research objectives, not the representativeness (number representation) of samples quantitatively. Because of that, CAR only demands the use of simple statistics, not complex.
- j. Intend to change reality, and learning situations to become better and meet expectations, not intending to build theory and test hypothesis.
- k. The objective of CAR is as the following:
- l. Fix and improve the quality of educational practices implemented by teachers in order to achieve learning objectives.
- m. Fix and improve learning performances implemented by teachers.
- n. Identify, solve and overcome learning problems in class for quality education.
- o. Improve and strengthen teachers' ability in solving learning problems and making the right decisions for students and classes taught.
- p. Explore and produce creations and innovations in education (such as approach, method, strategy, and media) that can be done by teachers for the quality improvement of processes and study results.
- q. Try out ideas, thoughts, tips, ways, and new strategies in teaching in order to improve education quality other than the innovative abilities of teacher.
- r. Explore education that is always insightful and based on research so that education can focus on the empirical reality of class, not only focusing on general impression or assumption.
- s. The four main steps that are interrelated in the implementation of classroom action research are often called as one cycle. Visually, the stages in every cycle can be described in Figure 1.

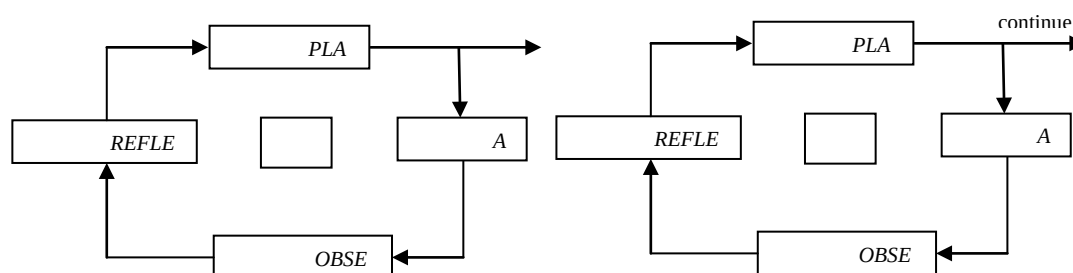


Figure 1. Classroom Action Research Cycle Model

In implementing actions or corrections, observations and interpretations are done simultaneously. In order for the implementation of action to be according to the rules of CAR, these six criteria need to be adhered to:

1. Research methodology should not disturb teachers' commitment as the implementer of education.
2. Data collection should not waste too much of the teachers' time.
3. Methodology should be reliable so that teachers can implement appropriate strategy within the classroom situation.
4. Problems addressed by the teachers should be in accordance with the ability and commitment.
5. Teachers should pay attention to several rules (ethics) connected to their assignment.
6. CAR should receive support from the school community.

2.3. Colligative Properties of Solution

The colligative properties of solution is the property of solution that do not depend on the type of solute but is only depending on the concentration of the particle of dissolved substance. The colligative properties of solution consists of two types, which are the colligative properties of electrolyte solution and colligative properties of non-electrolyte solution. Molecules of the components of solution directly interact in a mixed state. In the process of solvation, the attraction between the particles of pure components are split and replaced with the attraction between solvent and solute. If solvent and solute are both polar, a structure of solvent will be formed surrounding the solute which allows the interaction between solute and solvent to be stable.

If the component of solute is added continuously into the solvent, then at one point the components added could not be dissolved anymore. The quantity of solute in the solution is maximal, and the solution is known as *saturated*. Generally, the *solubility* of a substance is proportional to the temperature. The solubility of liquid in other liquid is generally less sensitive to temperature than solids or gas in liquid. The solubility of gas in liquid is generally inversely proportional to temperature.

2.4. Molality and Mole Fraction

In a solution, there are several substance properties that are only determined by the amount of dissolved particles. Because the colligative properties are determined by the amount of substance particles dissolved, there need to be knowledge about solution concentration.

2.4.1. Molality

Molality is the amount of mole solute in 1 kg (1000 gram) of solvent. Molality is defined as the following equation:

$$m = \frac{\text{massa}}{Mr} \times \frac{1000}{V}$$

Description:

m = molality of solution (mol/kg)

n = amount in mole of solute (g/mol)

V = volume of substance (L)

3. Method

The research was conducted in SMAN 9 East Jakarta in class XII (twelfth grade) involving two observers (chemistry teacher and principal or element of leadership) in the school. This research was conducted in 5 months period using two 2 cycles. Before the cycles, the students went through the assessment phase in which the students were tested to measure their initial ability and explore problems faced by the students which were linked to the desired competence.

In the first cycle, the researcher and the observers (teachers) surveyed the problems and difficulties faced by the teachers in order to increase students' interest and examination results of the chemistry subject (colligative properties concept). It was then continued with the discussion regarding the students' initial test results to determine the action plan to the problem. The determined action plan was to guide the students through teaching and learning, delivering the materials, describing and explaining the display in interactive multimedia, discussion, and test. The first cycle was completed in two lessons (2 x 45 minutes). The first 45 minutes lesson saw the teacher carrying out some learning activities and one of the researchers gave interactive software material about chemical bonding using the interactive multimedia. Discussion followed the next 45 minutes under the teacher's guidance. This is to explore understanding of the material shown earlier. Monitoring was done during the whole learning process using observation technique and recording. It also includes incidents and changes in behaviors, ways, and documentation technique towards situation and condition in class. Questions and problems that needed to be solved were also given. The monitoring data was then analyzed. The data and medium of collection are described in Table 1.

Table 1: Data and Media of Collection

Data	Medium of Collection
Participative observation result	Observation Sheet
Observation of class activity	Observation Sheet
Measurement of study result	Test Result Sheet

The second cycle was planned based on the analysis and reflection result from Cycle 1. Weaknesses of certain procedures from the first cycle were improved on in the second cycle. Only the materials delivered were the same but treatment was added. Now the students were divided into four groups using **jigsaw** puzzle. Then each group was given an assignment to reflect on what they saw and understand from the interactive learning media. Each group was then given tasks that are different from one another. Throughout the process, the students were asked by the teacher to find sources that they had prepared, either from books, internet search results, or from websites that explain about the colligative properties of solution. The students were then asked to present their discussion using concept mapping. They were advised to make it as interesting as possible so that it would be easier to understand. Later, students from all groups re-grouped. Each member had to now explain what they understood from their initial group so that every member in the new group now has the same understanding. At the end of the learning process, students were tested, similar to the first cycle.

4. Result and Discussion

In the first cycle, the 37 twelfth grade students in the Science class results is shown in Table 2, while the distribution of results of the second cycle is shown in Table 3. Based on the data collected, the initial average result of the students was 54.9. After cycle 1, the average result of the students was 56.8. After cycle 2, the average result of the students was 79.7.

Table 2: The distribution of results obtained in cycle 1

No.	Student Group	Total	Percentage
1	Students with test result <75	34 Siswa	89,47 %
2	Students with test result $75 < x < 85$	4 Siswa	10,53 %
3	Students with test result > 85	0 Siswa	0,00 %

Table 3: The distribution of results obtained in cycle 2

No.	Student Group	Total	Percentage
1	Students with test result <75	8 Siswa	21,05 %
2	Students with test result $75 < x < 85$	19 Siswa	50,00 %
3	Students with test result > 85	11 Siswa	28,95 %

Based on the result, there is a significant increase in the average students' test grades from cycle 1 (56.8) to cycle 2 (79.7). Possible explanation for the increase could be due to the more dynamic discussion. This type of discussion happened because every student was active in their group and had to explain again what they have learned to the other members in the newly appointed group. Another possible explanation for the increase in test grade is the concept mapping made by each group which increased their ability to memorize and understand the concept given. As such, we can conclude that the application of interactive learning media in the learning process is successful in improving the learning outcome of the students.

5. Conclusion

From the records and the results discussed above, it can be concluded that using interactive learning media can successfully improve the learning outcome of the twelfth-grade students in SMA Negeri IX Jakarta Timur in Colligative Solution in Chemistry.

References

- Akbar, M. F. (2010). Penggunaan Sifat Koligatif Larutan. Retrieved July 21 2011, from <http://indonesiakutercinta.wordpress.com/2010/08/13/penggunaan-sifat-koligatif-larutan/>
- Asmaini, M. J. (2008). Tips Menjadi Guru Inspiratif. Yogyakarta: Kreatif.Diva Pre.
- Arikunto, S., Suharjono, Supardi. (2006). Penelitian Tindakan Kelas. Jakarta: Bumi aksara.
- De Porter, B. and Hernacki, M. (2001). Quantum Learning.Membiasakan Belajar Nyaman dan Menyenangkan. Bandung : Penerbit Kaifa.
- Justiana, Sandri, and Muchtaridi. (2009). Chemistry for Senior High School Year XII. Jakarta:Yudistira.
- Lieberman. (1987). Education as a Profesion. New Jersey: Prentice Hall.
- Purba, M. (2007). Kimia Untuk SMA Kelas XII Semester 1. Jakarta: Erlangga.
- Ryan, L. (2000). Advanced Chemistry for You. UK: Nelson Thornes Publisher
- Sagala, S. (2003). Konsep dan Makna Pembelajaran: Untuk MembantuMemecahkan Problematika Belajar dan Mengajar. Alfabeta: Bandung.
- Sardiman (2005). Interaksi & Motivasi Belajar Mengajar. Jakarta: PT.Raja Grafindo Perkasa
- Silitonga, P. M. (2009). Pengaruh Kemampuan Awal dan Model Pembelajaran Terhadap Hasil Belajar Kimia SMA. Medan: FMIPA Unimed.
- Slameto. (1978). Belajar dan Faktor-faktor yang Mempengaruhinya. Jakarta: PT Bina Aksara.
- Suhardjono. (2009). Pertanyaan dan jawaban di sekitar penelitian tindakan Kelas dan tindakan sekolah. Malang: Cakrawala Indonesia.
- Suryosubroto. (2002). Proses Belajar Mengajar di Kelas. Jakarta: Rineka Cipta.
- von Glasersfeld, E. (1989). As quoted and retrieved July 21 2011, from http://repository.upi.edu/operator/upload/t_ipa_0706723_chapter2.pdf
- Zulfikri (2010). Penelitian Tindakan Kelas (Classroom Action Research). Retrieved July 21 2011, from http://pakguruonline.pendidikan.net/penelitian_tindakan_kelas.html

Increasing Students' Mathematical Creative Thinking Abilities through Realistic Mathematics Education Using ICT and Deduction

^aMiftahul SAKINAH, ^bSigid Edy PURWANTO

^{a,b}Department of Mathematics Education, The School of Teachers Training and Paedagogy, University of Muhammadiyah Prof. Dr. HAMKA, Indonesia
sakinahmiftahul@rocketmail.com, sigidmath@yahoo.co.id

Abstract: Mathematics courses should be given to all students especially those in the elementary school. It is vital to equip the students with the ability to think logically, analytically, systematically, critically, and creatively as well as the ability to cooperate. Mathematics learning in the classroom is believed to be less able to increase mathematical creative thinking abilities among students, as shown in the International Student Assessment (PISA) results in 2009. Indonesia's Mathematics education ranked 59 out of 65 countries. Other results released by the Trends in Mathematics and Science Study (TIMSS) in 2007 showed Indonesian students obtaining an average score of 397, far below Singapore and Malaysia where both countries had both obtained the average scores of 593 and 474 respectively. Due to the above reasons, the need to carry out the research was felt necessary. In realistic mathematics education, students are required to create their own modeling, and develop existing knowledge, thus find new knowledge that will be useful in the learning process. This approach requires students to interact, both with the teacher and other students in order to enable them to exchange ideas and knowledge. In the process of doing that, it is hoped that the mathematical creative thinking abilities will be formed. Learning in this context is supported by the use of ICT as a learning media that displays a real-world context for students. Deductive approach will be used as the comparison group in this study. Based on the results of the processing and analysis of data, it is shown that the mathematical creative thinking abilities of students taught using the ICT-assisted approach to realistic mathematics education is different from students who were taught using the deductive approach. Students taught using the ICT-assisted realistic mathematics education have higher averages. In other words, realistic mathematics education in ICT-assisted is suggested to be better than the deductive approach in improving students' mathematical creative thinking abilities.

Keywords: realistic mathematics education, deductive approach, creative thinking, ICT

1. Introduction

Indonesian students' mathematics learning outcomes in the recent period has decreased. According to the National Exam Results Indonesian Ministry of National Education, the average value of the national exams for junior high school mathematics in 2013 was 6.1. It is lower than the acquisition in 2012, which was 7.54 (Kemendikbud, 2013).

In addition, the results of tests Trends in International Mathematics and Sciences Study (TIMSS) held the International Association for Evaluation of Educational Achievement (IEA) suggests that mathematical ability of the grade 8th of Junior High School in Indonesia is still quite alarmingly low, where it is ranked 38 from 45 countries (Mullis, 2012). The grade 8th ability of the Junior High School in Indonesia for completing non-routine problems (mathematical problem) is very weak, but relatively well in resolving questions on facts and procedures.

These facts indicate contradictory phenomenon. It raises the question of what approach to be taken to increase students' mathematical achievement. How should mathematical instruction be given in order to have a positive impact on the development of students who are being educated to face the future?

Mathematics learning outcomes are the ability to think creatively. These include the high order thinking skills. One of the lessons that can raise and improve the ability to think creatively is to provide mathematical learning. It is described in the standard curriculum unit for basic education and secondary mathematics which stated that Mathematics is needed in order to equip students with the ability to think, and build creative thinking (Peraturan Menteri Pendidikan, 2006).

The study of mathematics in the classroom today is less able to raise and improve the ability to think creatively particularly mathematical creative thinking abilities of students. This happens because most teachers in Indonesia use the conventional or the traditional learning process. One example of traditional learning is learning through deductive approach (Ida, 2013).

Furthermore, interesting to note is the presence of discourse in mathematics learning paradigm revolution. This discourse is based on the conditions in which learning mathematics at this time is not just about counting activity. It is a human activity in living their everyday lives. According to Zamroni (2006), the development of science occurs when there is a paradigm revolution. For example in the development of mathematical knowledge, mathematics is stated as human activity, and that it is not just about numbers, but about life. This implies that learning mathematics is also learning about the meaning of life. This is consistent with one of the approaches in the learning of mathematics, namely realistic mathematics education.

Realistic mathematics education will facilitate students in planting concepts and enhance students' mathematical creative thinking abilities. This is where math is displayed into real figures that can be imagined. This is a realistic approach to mathematics learning of students involved in the learning process. They look at the learning process and create their very own models, thus encouraging creative thinking skills.

To increase the effectiveness of realistic mathematics teaching and learning approaches, teachers are advised to use the information and communications technologies (ICT). The use of ICT in the learning process uses a realistic mathematics education to help answer problems or issues in the learning process so that students can imagine within a realistic approach to learn Mathematics more effectively. In addition, the use of ICT can also increase the child's motivation to learn because it presents math in a more interesting way.

2. Theory

2.1. Student's Mathematical Creative Thinking

Creativity is the ability to produce a composition, product, or idea of what is essentially an unknown author. It can imagine activities which include formation of new patterns and combined information derived from previous experiences. This will result in a new situation and not only covers the establishment of sheer fantasy (Hurlock, 1992). Students' creative thinking ability can be measured by the fulfillment of indicators of the ability to think creatively. Indicators according to Torrance includes smooth/fluent thinking, flexibility, originality/novelty and detail/elaboration (Munandar, 2009).

Associated with the learning of mathematics, mathematical creative thinking abilities of students can be seen from (1) students' fluency constraint answers associated with math problems and address issues related to the math correctly, systematic and relevant, (2) diversity completing math problems and can change resolution existing mathematics to different problem-solving (3) find and give new ways of relating to the completion of math problems and (4) describe in detail how to go into details or how to solve the mathematical problem, which detail can be sentences, graphs and images.

There are levels in mathematical creative thinking abilities according to Siswono (2008): (1) a person is very creative (level 4) if he/she was able to demonstrate proficiency/fluency, flexibility and novelty or just show flexibility and novelty in solving problems or asking, (2) a person is creative (level 3) if he/she was able to show proficiency/fluency and novelty or shows fluency and flexibility in solving a problem, (3) a person is creative enough (level 2) if he/she was able to show it or show flexibility novelty alone, (4) a person said to be less creative when he/she was only able to demonstrate proficiency/fluency only in solving mathematical problems, and (5) the last level or level 0, which is classified as not creative.

2.1.1. *Realistic Mathematics Education ICT Assisted*

"Mathematic is a human activity", said Hans Freudenthal. This statement is the basis of Realistic Mathematics Education (RME). Realistic mathematical theory was first introduced and developed in the Netherlands in 1970 by the Freudenthal Institute which stated that mathematics should be associated with reality and mathematics is a human activity (Suharta, 2005). In Indonesia, the implementation of realistic mathematics (PMRI/Indonesia Realistic Mathematics Education) is still relatively new. PMRI has been tried in some elementary school (SDN/MIN) in Indonesia and so far it has shown good results for the advancement of mathematics learning activities, one of which as admitted by Ratini (2005), third grade teacher MIN Yogyakarta II states that through learning fractions with PMRI approach, students can understand math, art and creativity thrive soul. To the level of Junior High School or junior secondary school there is no programme devoted to applying realistic mathematics learning, but efforts in that direction have been tried by IndoMath with training programs for junior high school teachers (Hadi, Plomp, Suryanto, 2001).

This realistic mathematical approach emphasizes the importance of pupils known real context and the construction of mathematical knowledge by the student himself. The context of real-world problems is the main part of mathematics (Tarigan, 2006). Real or realistic is not just something real and concrete for students but can be a context that can be imagined by the students. In realistic mathematics education, there are three main principles. According to Gravemeijer, there are Guided re-invention, Didactical Phenomenology and Self-developed Model (Supinah, 2008).

Realistic mathematics education has some characteristics that differentiate it from other approaches. Treffer (Wijaya, 2012) formulates five main characteristics of realistic mathematics approach, namely (1) the use of context, (2) use the model for progressive mathematics process, (3) utilization of construction student outcomes, (4) interactivity and (5) linkages. The use of context of realistic mathematics learning is the first step in building and finding a math concept through mathematical process. The mathematical process comes from horizontally to vertically mathematical process. Mathematics in the horizontal process starts from the issue - a matter of context, then students define for themselves the language and symbols on its own. Vertical mathematics is a process that occurs within the system itself, which include mathematical concepts such as the use of multiplication, division, addition or subtraction.

In mathematics realistic education students are involved in the learning process of making models by the students themselves. The use of models in realistic mathematics education serves as a bridge of mathematics from the informal to formal mathematics or the bridge between horizontal mathematical processes to vertical. Realistic mathematics learning approach feature either active interaction with students or student interaction with student teachers. Teachers' interaction with students in the learning process can be seen in the presence of a teacher asking some questions to the students. Student's questions can also lead to students' interaction among students. "Linkages" means that in realistic mathematics education, mathematics should be interconnected to other subjects, so that the subject of mathematics learning is integral and intact. To understand these characteristics, teachers should know that the mathematical terms are interrelated.

ICT (information and communication technologies) has two aspects: communication technology and information technology. This includes information technology hardware and software to perform a task such as capturing, processing, transmit, store, retrieve, manipulate or display data. Communication technology is related to data processing and data transferring from one device to another. Information and communication technologies have strong links between information technology and information processing systems. Communication technology aims to send information that have been processed (Rusman et al, 2011: 83). Microsoft power point is used in this ICT-assisted learning of realistic mathematics education. Power point is used to display the contextual issues related to real life, so hopefully the students may be interested to resolve the problem.

2.1.2. *Deductive Approach*

This approach is characterized by a presentation given at the beginning of the learning where teachers provide definitions and terms. Deductive approach (Sagala, 2005) is a process of reasoning approach which starts from the general to special circumstances. This approach begins with the present rules, where the general principle is followed by giving an example or a specific example of the application of topics that have been submitted. The general principles then move into

specific circumstances. Step by step deductive approach as follows: (1) The teacher explains the material to be delivered, (2) Teacher gives examples of questions from material that has been described, (3) Teachers provide an opportunity for learners to record the material that has been described and provide an opportunity to ask the teacher and occasionally ask about the material that has been presented to the students. (4) The teacher then provide tasks to the learners.

3. Research Methodology

This study uses a Quasi Experiment design. Data sources in this study were students of VIII-5 class as the class were taught by a realistic mathematics education ICT assisted (experimental class), and students of VIII-3 class as a class taught by a deductive approach (control class) in SMPN 106 SSN Jakarta registered in the first semester of 2012/2013 academic year. Experimental class totaled 33 students and a control class with 34 students. Data is collected using a written test with a test item instrument description. It is to measure the ability of students to think creatively in mathematics.

4. Data Analysis

To analyze the data obtained in the study used statistical test using t-test, but previously performed tests of normality and homogeneity test as a condition of doing data analysis. (1) normality test is used to determine whether the sample used normally or not, so it can determine the types of statistics that will be used later. Normality test used in this study is the Lilliefors test, (2) homogeneity test is to show that the variance of the samples to be compared were not significantly different. Testing homogeneity in this study used the Fisher test, (3) t-test was performed to determine which hypothesis after the data were normally distributed and homogeneous.

5. Results

5.1. Validity

Out of the 12 obtained about the creative mathematical thinking, nine were valid and three were not valid.

5.2. Reliability

Reliability calculation with regards to the mathematical creative thinking ability showed $r_{\text{result}} = 0.766$ where it has a value greater than $r_{\text{table}} = 0.361$. Thus, it can be concluded that the matter of mathematical creative thinking abilities of students in the subject of two-variable linear equation system is reliable and fit for use as a research instrument.

5.3. Data Descriptions

5.3.1. Data Classes Taught by Realistic Mathematic Education Approach ICT Assisted

The research data obtained from the mathematical creative thinking abilities test among students in the experimental class taught classes with a realistic approach to mathematics instruction on the subject of ICT assisted linear equations system of two variables. Of the tests that have been done scores ranged between 6 to 27, with the average score of 12.39; median of 11.668; modes of 10.664, and the standard deviation of 5.178.

5.3.2. Data Classes Taught by Deductive Approach

The research data obtained from tests of mathematical creative thinking abilities of students in the control class is a class that is taught by a deductive approach on the subject of two-variable system of linear equations. Of the tests that have been done, obtained scores ranged from 1 to 17, with the average score of 7.588; median 6.875; modes of 5.50, and a standard deviation of 3.978.

5.4. Test Result Analysis Data Requirements

5.4.1. Normality Test

Having tested the test, results obtained Lilliefors $L_{\text{result}} = 0.1380 < 0.1542 = L_{\text{table}}$ (class of realistic mathematics education ICT assisted) and $L_{\text{result}} = 0.1260 < 0.1519 = L_{\text{table}}$. Thus, it can be concluded that both classes have a normal distribution.

5.4.2. Homogeneity Test

The homogeneity of two classes will be tested using the Fisher test. Results obtained are as the following $F_{\text{result}} = 1.694$ and $F_{\text{table}(0,95)} = 0.556$ and $F_{\text{table}(0,05)} = 1.798$. As $F_{0,95(32,33)} = 0.556 < 1.694 = F_{\text{result}} < 1.798 = F_{0,05(32,33)}$ it can be concluded that both sets of respondents has the same conditions or homogeneous variance.

5.5. Hypothesis Testing Results

Research hypothesis was formulated stating that there is a difference between students who were taught realistic mathematics education and deductive approach to mathematical creative thinking abilities. Proposed hypotheses were tested using t-test. And the values obtained from the list-t distribution with significance level $\alpha = 0.05$ and degrees of freedom (df) = 65 to test the two parties, in the $t_{\text{table}} = 1.9983 = -1.9983$. With testing criteria receive H_0 if t_{result} between -1.9983 and 1.9983. The calculation shows that t is not among the criteria of acceptance of H_0 is $t = 4.2650 > -1.9983 = t_{\text{table}}$ or $t = 4.2650 > 1,9983 = t_{\text{table}}$ which indicates that H_0 is rejected. Rejection of H_0 indicates that there are differences in mathematical creative thinking abilities among students who were taught using the deductive and the ICT method.

6. Results

Realistic ICT assisted mathematics education can make a difference in mathematical creative thinking abilities of students. Learning process through realistic mathematics education displays mathematics in the real world context. Mathematical learning becomes meaningful because students who are guided and motivated by teachers can find for themselves the mathematical concepts through the exploration of the real world. As students are included in the learning process, they were able to make generalization and construction of knowledge to complete the problem given. The learning process encourage enhancement of students' mathematical creative thinking abilities. The use of ICT in teaching realistic mathematics approach also made learning more effective because ICT is used to help illustrate mathematical problems.

Interaction is one of the characteristics of realistic mathematics education approach assisted ICT. Here students are encouraged to exchange their imaginations and ideas. Through construction and reconstruction, students will be more creative in answering math problems. The use of real-world context and orientation which changes from the teacher focused to the students' learning processes provides a positive impact in improving students' mathematical creative thinking abilities.

References

- Hadi, S., Plomp, T., & Suryanto. (2001). *Introducing Realistic Mathematics Education to Junior Highschool Mathematics Teachers in Indonesia*. (accessed 30th March 2007, from <http://www.math.uoc.gr/~ictm2/Proceedings/pap279.pdf>).
- Hurlock, Elizabeth B. (1992). *Perkembangan Anak*. Jakarta: Erlangga.
- Kemendikbud. (2013). *Hasil UN SMP-Sederajat Tahun Ajaran 2012-2013*. Jakarta: Kemendikbud.
- Mullis, Ina V.S., et.al. (2012). *TIMMS 2011 International Results in Mathematics*. Chestnut Hill: TIMSS and PIRLS
- Munandar, Utami. (2009). *Pengembangan Kreativitas Anak Berbakat*. Jakarta : Renika Cipta.
- Ratini. (2005). *Pembelajaran Pecahan dengan PMRI Lebih Bermakna*. Buletin PMRI (Pendidikan Matematika Realistik Indonesia). Edisi VI – Februari 2005.
- Sagala, Syaiful. (2005). *Konsep dan Makna Pembelajaran*. Bandung: CV Alfabeta
- Siswono, Tatag Yuli Eko. (2008). *Model Pembelajaran Matematika Berbasis Pengajaran Dan Pemecahan Masalah Untuk Meningkatkan Kemampuan Berpikir Kreatif*. Unesa University Press.
- Suharta, I.G.P. (2005). *Matematika Realistik Apa dan Bagaimana*. Jurnal Pendidikan dan Kebudayaan Edisi 38, Pusat Data dan Informasi Pendidikan, Balitbang – Depdiknas

- Supinah. (2008). *Pembelajaran Matematika SD dengan Pendekatan Kontekstual dalam Melaksanakan KTSP*. Yogyakarta: Pusat Pengembangan Pendidikan dan Tenaga Kependidikan Matematika.
- Tarigan, Daitin. (2006). *Pembelajaran Matematika Realistik*, Jakarta: Departemen Pendidikan Nasional.
- Wijaya, Ariyadi, (2012). *Pendidikan Matematika Realistik*. Yogyakarta: Graha Ilmu.
- Zamroni. (2006). *Pergeseran Paradigma Pembelajaran Matematika Sekolah*. Makalah Direktorat Profesi Pendidik. Direktorat Jenderal Penjaminan Mutu Pendidik dan Tenaga Kependidikan.

Exploring Teachers' Cultural Perception of ICT in Nigerian Schools through a Qualitative Approach

Arit Uyouko UYOUKO^{a*} & Su Luan WONG^b

Faculty of Educational Studies, Universiti Putra Malaysia, Malaysia^{a,b}

Collage of Education, Afaha Nsit, Akwa Ibom State Nigeria^a

*uobonganwan@rocketmail.com

Abstract The purpose of this study was to explore teacher's cultural perception of ICT in Nigerian Schools. The study was guided by three research questions and used the qualitative method, with a case study as a strategy. Interviews were employed to collect data about teacher's cultural perception of ICT in Nigerian schools. Findings from the interview revealed that teachers are incompetent and blame lack of ICT facilities and access for this inadequacy. All five participants demonstrated that their current ICT status did not match up with global standards. Findings also revealed reservations about software and materials on the internet as being inappropriate to norms and values of the country. Findings of this study are important for policy makers and stakeholders in the Nigerian education system.

Keywords: Cultural perception, ICT, teachers, Nigerian schools.

1.0 Introduction

In Nigeria, as in many parts of the world, national education reform has proven to be a complex process with implementation of policy mandates competing against the influence of strong social and contextual factors. Although Information and Communication Technology (ICT) is now at the centre of education reform efforts, not all countries are currently able to benefit from the developments and advances that technology can offer. Much research in the area of technology integration in education has been conducted in technologically advanced countries, but little in the developing countries and few statistics are available from developing countries (Jhurreev, 2005).

Nigeria is a developing country with a large population. It is a country with abundant natural resources. Since its independence from the British in 1960, education for all has become the mission of different governments in Nigeria. Starting from the early 1900s, the Federal Republic of Nigeria has made tremendous progress in the field of education by introducing technologies in schools. The Nigeria's National Policy for Information Technology of 2012 is preceded by the National Policy of 1988 and 2001, which brought about the introduction of computer education in the nation's secondary school system. The goal of the new National ICT Policy, 2012 is to provide a framework for streamlining the ICT sector and enhancing its ability to help address some socioeconomic and development challenges while facilitating the transformation of Nigeria into a knowledge based economy. Transformation to a knowledge based economy requires significant investment in the development of ICT skills (FME, 2007; FRN, 2001, 2006).

The policy has a sustained program to build a critical mass of ICT skilled personnel, integrate ICT into the national education curriculum, train and retool teachers and facilitators at all levels to enhance their ICT competence. The World Bank (Bank, 2007) report emphasized the pertinent role of the teacher in the effective utilization of this new global innovation and practice. It opines that it is not the presence of technology itself that stimulates significant changes inside a school. Without the involvement of the teacher and staff most students may not take full advantage of all available potential on their own and will not enable present school children to appreciate and use the computer in various aspects of life and in future employment. The reality of technology and market convergence implies that existing policies relating to the ICT sector in Nigeria are in need of critical review, most of the objectives in existing policies have been overtaken by technological advancement and market transformation worldwide.

In the face of educational reforms in Nigeria's ICT national policy, this paper explores the personal, social, and context-related factors that Nigerian teachers perceive could influence their utilization of ICT in teaching in the context of technology-oriented instruction, a central component in the new ICT policy.

1.1 Education and ICT

Education is not only limited to teaching the students according to prescribed syllabus at a specific school level. It has much broader objectives, goals and other concepts. Thus, education is becoming an increasingly important tool to combat poverty and to establish a modern nation. Feature of modern society is the penetration of information technologies in all spheres of life, including schooling. In general, the new technologies have been recognized to play a valuable role in developing and improving the teaching and learning situations. (Al-Zaidiyeen, Mei, & Fook, 2010). According to Cavas, Cavas, Karaoglan, and Kislal (2009), ICT plays a critical role in information societies' educational systems. In these societies, the stakeholders of educational policy, redesign and reconstruct their educational systems based on the new educational paradigms such as constructivist theory so that both teachers and students develop the necessary knowledge and skills sought in this digital age. The emergence of the knowledge-based economy has resulted in educational reforms in many developed and developing countries across the world. In essence, these reforms aim to develop active learners to work collaboratively with others to construct knowledge. Pedagogically, they demand a teaching practice that is learner-centred and constructivist-oriented (Jimoyiannis & Komis, 2007). Hence, most countries around the world are focusing on approaches to integrate ICT in learning and teaching to improve the quality of education by emphasizing competencies such as critical thinking, decision-making, handling of dynamic situations, working as a member of a team, communicating effectively among others. Also governments especially in developing countries have tried to improve their national programs to integrate ICT into education. ICT is an indispensable part of our contemporary world. The field of education has certainly been affected by the penetrating influence of ICT worldwide and in particular developed countries (Yusuf, 2005). ICT has made an impact on the quality and quantity of teaching, learning and research in educational institutions. The benefits of ICT also show that it enhances teaching and learning through its dynamic, interactive, flexible, and engaging content. ICT provides real opportunities for individualized instruction, it has the potential to accelerate, enrich and deepen skills; to motivate and engage students in learning; to help relate school experiences to work practices; to help create economic viability for tomorrow's workers; contributes to radical changes in school; to strengthen teaching, and to provide opportunities for connection between the school and the world. Yusuf (2005) further state that the pervasiveness of ICT has brought about rapid technological, social, political, and economic transformation, which has eventuated in a network society organized around ITC.

All societies are cultural constructs, it is important to understand culture as the set of values and beliefs that inform and motivate people's behaviour as stated by Castells (2004). Similarly Albirini (2006), informs that studying teachers' cultural perceptions is particularly important in developing countries where ICT is not usually part of the culture. Due to its novel presence in society at large and in schools in particular, ICT may not be well received by developing-country teachers under various cultural influences. Nigeria as a developing country falls along this line of thought. Albirini (2006) further states that many technology experts have pointed out that the integration of ICT in education should occur in the light of the cultural conditions of the country and the prevailing school culture.

Grainger and Tolhurst (2005) in their study showed that there are a wide range of factors which influence educators' under-utilization of ICT in their teaching. These include access to resources, such as quality of software and hardware, also ease of use, incentives to change, support and collegiality in their school, school policies, commitment to professional learning and their background in formal ICT training. It is believed that capabilities and constraints determine the efficacy (real and perceived) of an individual's taking particular actions. For many teachers who may have the capability to use ICT, the lack of self-confidence in using the technology is noted to be a strong limiting factor to its use (BECTA, 2003). Research in the field of teachers' use of technology in the classroom identifies a complex pattern of interrelated factors that are assumed to be determinants of the successful utilization of ICT in teaching. According to Player-Koro (2012)

research classifies factors that facilitate (or act as barriers to) the use of ICT in schools by teachers as either arising from the external environment or the personal characteristics of teachers –including the beliefs, values and attitudes that are felt likely to influence them.

A study conducted by the Global Information Technology in 2005 used the Networked Readiness Index (NRI), covering a total of 115 economies in 2005-2006, to measure the degree of preparation of a nation or community to participate in and benefit from ICT developments. Nigeria was ranked 90th out of the 115 countries surveyed. United States of America topped the list, followed by Singapore, Denmark, Iceland, Finland, Canada, Taiwan, Sweden, Switzerland and the United Kingdom etc. Likewise, Nigeria was ranked 86th out of 104 countries surveyed in 2004 which shows a decline in the country's preparedness to participate in and benefit from ICT developments. Similarly, a study by Nigerian Information Technology Professionals in America in 2002 indicated that given the current ICT penetration, it may take Nigeria 50 years to catch up with America on the aspect of PC count per household (Yusuf, 2006). ICT application and use will prove beneficial in improving Nigeria's educational system and giving students a better education. A technologically-advanced workforce will lead to ICT growth in Nigeria, with the potential to improve military technology and telecommunications, media communications, and skilled ICT professionals who will be well-equipped to solve ICT problems in Nigeria and other parts of the world (Goshit, 2006).

The concept of culture points at the shared way of life of a group of people which influences people's behavior, perspectives, values and understanding (Berry, Poortinga, Segall, & Dasen, 2002). Sang (2010), states that perceptions are cognitive processes that build on internal and external experiences. Similarly, Wigfield and Eccles (2000) view perceptions as the personal translations of these experiences. As such, the opinions of colleagues or the school team will invoke perceptions in teachers. Teachers seem to adopt different cognitions and ICT integration, depending on their socioeconomic and regional position, their gender, their teaching experience, the subject domain they teach, and the levels of study years for pre-service teachers. Considering the nature of beliefs, teachers' educational beliefs may be largely shaped by culturally shared experiences and values. Teaching is a cultural activity and thinking about teaching and learning is informed by culturally shared ideas about teaching and learning (Correa, Perry, Sims, Miller, & Fang, 2008). In this study cultural perception is operationally defined as the value, habits, ability to use and apply technology and software in their instructional process, moving away from the norms of society and school. Norms are the established patterns of behavior that tell members of the system what behavior is expected (Rogers, 2010).

There is a clear consensus that culture must have a definite influence on the design and use of ICT (Chai, Hong, & Teo, 2009). The researcher's further argue that culture plays a mediating factor that influences how teachers relate their beliefs to ICT use. The social and cultural contexts in which ICT resources are perceived and used by teachers are key influences in the development of a range of personal and professional practices. Lee, Choi, Kim, and Hong (2007), conducted a study on the relationship between user's cultural profiles and technology adoption in the context of the mobile internet. Findings from this study of large scale on-line surveys in Korea, Hong Kong, and Taiwan indicated that cultural factors have a significant influence on users' adoption perception of mobile internet services. Concluding that, cultural differences are contributing factors in the adoption of technology, particularly in developing countries.

Sutherland, Armstrong, Barnes, Brawn (2004) reported on the findings of the InterActive Education Project conducted in the United Kingdom in which teachers and researchers worked together to develop and evaluate initiatives focused on using ICT to enhance learning in curriculum areas that students would normally find difficult. The study was conducted over a two year period and involved 54 teachers from both primary and secondary schools. The project was predicated on the view that ICT in and of itself does not enhance learning but rather how it is incorporated into learning activities is what makes the difference.

The integration of ICTs in several subject areas including Modern Studies, Languages, Science and the Arts were examined. The data collected revealed that different subject cultures impact differently on how ICT is used in the classroom with History and Geography teachers appearing to be the most technophobic. Sunderland et al. (2004) found that "...for some subject areas and for some teachers, ICT was seen as a Trojan Horse, secretly bringing in new approaches to learning that conflicted with the deep grammar of the subject" (p. 417). However, despite this

obvious aversion to technology use in the classroom, the history teachers who participated in the project reported several positive outcomes with regards to ICT integration in the projects implemented. Teachers reported marked improvements in the writing skills of lower ability students, increased levels of interaction among students, greater student enthusiasm and engagement and an increase in confidence for both the teacher and the students.

Rogers' (2010) theory of Diffusion of Innovations identifies the Social System as an important parameter in the innovation diffusion process. The social system denotes the social context in which the innovation diffuses. The structure of the social system affects diffusion in many ways. Rogers points specifically to the effects of the social norms on the rate of innovation adoption. Norms are the established patterns of behaviour that tell members of the system what behaviour is expected. There is, however, evidence that adoption rates differ significantly across countries with similar economic situations (Meijer, 2001; Van Ark, Inklaar, & McGuckin, 2003). A possible explanation may be that the meaning attributed to technologies differ among people, depending on their socio-cultural attitudes. Hence, the socio-cultural ambience, perceived values, institutions and political atmosphere might influence the perception of the individuals within a society in a certain way, and these factors may consequently impact the adoption decisions (Erumban & de Jong, 2006).

1.2 The purpose of the Study.

This study aims to provide insights into the immediate challenges teachers face and teachers' cultural perception of ICT and its benefits and how it might be better supported.

The major research questions the study seeks to explore are as follows:

- 1) What are the cultural perceptions among teachers' towards the use of ICT for education?
- 2) What are the levels of ICT use for educational purposes by teachers'?
- 3) What are the teacher's views about current and future perception towards ICT in Nigerian schools?

2 Methodology

2.1 Sample and Data Collection Procedures

This study adopted a qualitative method of an exploratory nature, with a case study strategy for data collection. The study seeks to explore teachers' cultural perception towards ICT and factors identified as potentially influencing teachers' perception. Interviews became a source of major data collection to explain issues and also to gain a deeper understanding of teachers' Cultural Perceptions and ICT use. For the purpose of this study, five respondents were selected to participate. This study was conducted in Malaysia where the five respondents are pursuing their PhD at Universiti Putra Malaysia (UPM). The criterion for choosing the interviewees were their being Nigerians with 10 – 20 years of teaching experience, all five respondents are PhD students, who had very low levels of computer competence, computer access, and computer training prior to their candidacy, while also maintaining their perceptions towards ICT in education. Respondents were interviewed in order to gain a better understanding of their cultural perception, given that interviews were especially helpful to obtain information that might be difficult to acquire including first-hand knowledge of people's feeling and perception (Salkind, 2012). The interview statements was developed by the first author and took into account the teachers' perceptions of the cultural value, relevance, and impact of ICT as it relates to both Nigerian scholastic and national cultures.

The interview involved 12 semi structured questions and allowed for open-ended comments. Questions probed on the participants' views about the entry of ICT into Nigeria and school, computer attributes, computer competence/access /training and general cultural perceptions, also if such perceptions were positive/negative towards ICT. The interview sought to investigate participant's future plans in terms of increasing their computer competence/ access/ training as well as their suggestions about the training opportunities that they would like. Lastly, they were allowed to add open comments about their experiences as student teachers in UPM. The interview instrument was pilot tested on one participant to ensure that the questions were comprehensible, this participant was not part of the study. Due to the smooth flow of the pilot interview and the positive feedback, no change was made after the pilot study. All interviews lasted between 20-30 minutes of four sessions

each, the interviewing session took into account convenience of the participant's availability taking note of their work schedule. Interview was audio taped and notes were taken.

The first author took time to explain to all participants about the objective of the study, the confidentiality of their response and possible publication of the study. Participants were also informed that their participation in the study was voluntary and could withdraw if they wish to at any point in the study. The result of the study might not be generalized to teachers in the country. Given the self-reporting nature of this study, it will be possible that the teachers will over rate or under rate their proficiency, and will not reflect the true nature of teachers' cultural perception.

3. Findings and Discussion

In this study two themes and two sub-themed emerged from the responses to the 12 interview questions. Findings are classified and presented in Table 1.

Table 1: Emerging sub-themes

Themes	Outcomes
Cultural perception	All see the web as foreign and course-ware not appropriate to norms and nation value. Want software to suit the national value. Comfortable with text books.
Infrastructure Facilities	Insufficient computer laboratories and poor maintenance. Desktop computers installed with archaic operating systems. No central database - still file processing system is used. Most of the time down even during school hours. Obstacles - Poor support from school administrators. Negative attitude of teachers. Administrative burden – many tasks still manual or have other people search the web for them even for email.
Computers	Limited; Notebook computers are purchased by teachers for personal use.
Skills	ICT Skills of Teachers - Generally poor. Request for more training.

3.1 Cultural Perception

As regards to cultural perception towards ICT, participants were of the view that the internet did not have enough software for national education and information on the country in terms of traditions and culture, they expressed the fear of generations losing their identity to information posted by the internet.

“My concern is about the students who will have access to foreign materials that are not the custom and values we hold in Nigeria. It is all American and European History and when mention is made of the country it is in the negative”

Findings from Li and Kirkup (2007) in their study of cultural perception reveals perceptions held by educators, they state that tools and machines reflect the values of the culture in which they are designed. The origin of the Internet is an American technology. It has been argued that ICTs are racially white, Western, male artefacts and that the Internet itself overtly embodies American cultural qualities in terms of its language and technical users' values (Chen, 2007). These cultural issues have been given attention recently by educators. Collis and Messing (2001) argue that culture is a critical factor in influencing people's acceptance and use of Internet-based learning resources. It is not surprising that American/English makes up 80% of the language of Web sites on the Internet. Li and Kirkup (2007) further state that cross-cultural studies of people's perceptions of

computers that have been done suggest that, in different cultures, people might have different perceptions and uses of computers and the Internet.

However, motivated by the prospect of greater economic, social, educational and technological gains, both developing and developed countries, are bringing about education reform, with a clear focus on ICT integration in education. Nations have recognised not only the positive effects of technology in education, but also the pivotal roles that it plays in securing jobs in the competitive job market of the 21st century

Having been exposed to ICT during their studentship all participants admit that ICT use is not difficult, all respondents are in support of e-library, social network, internet as a source for information for self- development and materials for teaching students. On school culture, concern by the respondents were that if computers are to be used in teaching, the Ministry of Education should prepare programs that educate students morally and culturally about the improper materials viewed on the Internet.

3.2 *Infrastructure Facilities*

In answering the second research question, participants indicated that computer laboratories in their respective schools are inadequate and facilities absolute. They pointed out that there is need for a classroom setting which is facilitated with ICT tools such as computer, projector, TV and video, overhead projector, internet and other instructional technology. They mentioned that the standardization of technology in every classroom and some special classrooms will facilitate high utilization of the technology. This is line with Ely's 1990 third condition of change which states that the things that are needed to make the innovation work should be easily accessible. Resources are broadly defined as those tools and other relevant materials that are accessible to assist learners to acquire learning objectives (Ely, 1990). Innovations are less likely to succeed if adequate resources are not provided. Such as computers, classroom remodelling, personnel salaries and teacher training, it also covers things so small that they may be over looked. Some schools are unable to supply textbooks. If resources are unavailable, acquisition of learning objectives will be impeded.

"Computer department only can use the computers, 80% of the teachers do not know how to use the internet to search for material. None utilization means no access, no training, no competence"

Teacher "C"

"I don't even bother with the school computer laboratories, its either one problem or the few times I have had reason to be there"

Teacher "E"

However, in most developing countries like Nigeria, the potential of ICTs to support pedagogy is yet to be fully realized. To date most of the attention both on policy and research has been on how the lack of infrastructure and access to technology affect the use of ICT in pedagogy (Koo, 2008). The second research question therefore identified two sub themes; first is personal computers for teachers use and skills needed for ICT implementation.

3.2.1 *Computers and Skills*

All five participants said that they own laptops, but still lack basic skills in ICT because computers are not allocated for staff to use. The teachers added that due to this limitation, they find it rather difficult to use ICT for teaching. The teachers have to take up short courses in computer literacy as requirements by school administration not necessarily for ICT use but to keep their teaching jobs. The participants suggested that appropriate skills training on the use of MS Word, MS Excel and MS PowerPoint be given to all teachers at an on-going basis. One participant said:

"I am not comfortable with the way things are, we are losing out on what is going on with the rest of the world. We should have the opportunity to network with other teachers all over the world. Prior to coming to UPM my typing was done at a business center by a paid typist. I had to learn to type when I got here."

Teacher "A"

“I spent a lot of time putting up my notes, I write first then type. On PowerPoint preparation that is a different story, didn’t quite know the A to Z of it”.

Teacher “B”

Player-Koro (2012) states that the motives and arguments in favour of implementing ICT come from many directions; both advocates inside schools and, more often, from outside, the researcher stated further that despite the positive results obtained in small-scale, often experimental, studies and the considerable effort and resources put into educational computing by many governments, there is still a lack of evidence that ICT has actually enhanced educational standards (Nivala, 2009; Ottestad, 2010). Reasons for this listless state have been reported, ranging from technical factors such as a lack of technology and software in schools and the limited expertise of teachers regarding ICT use to other factors such as teachers’ beliefs and knowledge about how to integrate ICT into teaching.

3.3 Current and Future Views Held by Teachers

On participant’s views about current and future perception towards ICT in Nigerian schools, findings from this study revealed that lack of ICT resources and infrastructure facilities in schools as the most common reason that impedes the utilization of ICT in teaching and learning. Computers in fact are available in school for only computer education departments but the interview findings revealed that many of them are out of order. ICT facilities in rural schools are barely there, urban schools at this point are still at the bare minimum with proper computer laboratories and those that were built were not to specifications, all of these obstacles are responsible for none utilization. All have a positive attitude towards ICT utilization, and see continuous training to update teachers’ ICT skills and appropriate training on when, when not and how to use ICT tools appropriately in classroom situations as necessary to fully realize the benefits of ICT integration, since ICT skills gained at courses are being used to the maximum to further the participants’ qualifications and promotion, but such knowledge are not being used to improve their presentation skills for the benefit of students.

“I have attended quite a number of those workshops on ICT’s, I had to sit in just to sign the attendance. I am just fine with Textbooks.

Teacher “D”

This finding is in line with the study by Rogers, (2010), Rogers states that people’s attitudes towards a new technology are a key element in its diffusion. Regardless of the quantity of technology placed in classrooms, the key to how those tools are used is the instructor (Gülbahar, 2008). Understanding the factors contributing to the utilization of technology and the possible relations of these factors will lead to the education technology-competent teachers.

4. Conclusion and Suggestion

The aim of this study was to explore cultural perception held by Nigerian teachers towards ICT in Nigerian schools, prior to UPM. Views held by all participants towards ICT were based on fear of the unknown, such as fear of being replaced by technology and making them redundant. Participants held a negative perception towards social network, and belief information posted on them as being inappropriate for school and national value, postings had all the foreign elements about them which were not in norms with social norms and views held. A major interesting finding from the study is the lack of basic facilities and skills needed to implement ICT. Thus there is a need to put in place necessary structures in schools for competence building and access to ICT for daily usage to erase pre-held negative perceptions towards ICT by teachers.

References

- Al-Zaidiyeen, N. J., Mei, L. L., & Fook, F. S. (2010). Teachers' attitudes and levels of technology use in classrooms: The case of Jordan schools. *International Education Studies*, 3(2), 211.
- Albirini, A. (2006). Teachers' attitudes toward information and communication technologies: The case of Syrian EFL teachers. *Computers & Education*, 47(4), 373-398.
- Bank, W. (2007). About the ICT Sector Unit *Tpoics*: World Bank Group.
- BECTA. (2003). What the research says about using ICT in Maths.
- Cavas, B., Cavas, P., Karaoglan, B., & Kislal, T. (2009). A study on science teachers' attitudes toward information and communication technologies in education.
- Chai, C. S., Hong, H.-Y., & Teo, T. (2009). Singaporean and Taiwanese pre-service teachers' beliefs and their attitude towards ICT: A comparative study. *The Asia-Pacific Education Researcher*, 18(1), 117-128.
- Chen, C. H. (2007). Cultural diversity in instructional design for technology-based education. *British Journal of Educational Technology*, 38(6), 1113-1116.
- Collis, B., & Messing, J. (2001). Usage, attitudes and workload implications for a Web-based learning environment. *Research in Learning Technology*, 9(1).
- Correa, C. A., Perry, M., Sims, L. M., Miller, K. F., & Fang, G. (2008). Connected and culturally embedded beliefs: Chinese and US teachers talk about how their students best learn mathematics. *Teaching and Teacher Education*, 24(1), 140-153.
- Erumban, A. A., & de Jong, S. B. (2006). Cross-country differences in ICT adoption: a consequence of culture? *Journal of World Business*, 41(4), 302-314.
- FME. (2007). *Education Reform Act. Arrangement of Parts (Education Sector Reform Bill)*. Abuja: Federal Ministry of Education.
- FRN. (2001). *Nigeria national policy for information technology* Federal Republic of Nigeria: Federal Republic of Nigeria Retrieved from <http://www.nitda.gov/docs/policy/ngitpolicy.pdf>.
- FRN. (2006). *Government in action*. Federal Republic of Nigeria: Federal Republic of Nigeria Retrieved from http://www.nigeriafirst.org/article_2090.shtml.
- Goshit, T. (2006). Nigeria's need for ICT: SP. 259 technology and policy in Africa. Retrieved November, 23, 2006.
- Grainger, R., & Tolhurst, D. (2005). *Organisational factors affecting teachers' use and perception of information & communications technology*. Paper presented at the Proceedings of the 2005 South East Asia Regional Computer Science Confederation (SEARCC) Conference-Volume 46.
- Gülbahar, Y. (2008). ICT usage in higher education: A case study on preservice teachers and instructors. *The Turkish Online Journal of Educational Technology*, 7(1), 32-37.
- Jhurreev, V. (2005). Technology Integration in Education in Developing Countries: Guidelines to Policy Makers. 6 (4), 467-483. Retrieved from <http://ehlt.flinders.edu.au/education/iej/articles/v6n4/jhurree/paper.pdf>
- Jimoyiannis, A., & Komis, V. (2007). Examining teachers' beliefs about ICT in education: Implications of a teacher preparation programme. *Teacher development*, 11(2), 149-173.
- Koo, A. C. (2008). Factors affecting teachers' perceived readiness for online collaborative learning: A case study in Malaysia. *Educational Technology & Society*, 11 (1), 266-278.
- Lee, I., Choi, B., Kim, J., & Hong, S.-J. (2007). Culture-technology fit: effects of cultural characteristics on the post-adoption beliefs of mobile internet users. *International Journal of Electronic Commerce*, 11(4), 11-51.
- Li, N., & Kirkup, G. (2007). Gender and cultural differences in Internet use: A study of China and the UK. *Computers & Education*, 48(2), 301-317.
- Meijer, E. M., & Ling, R. (2001). The adoption and use of ICT services in Europe: Potential acceptance of mobile broadband services: EURESCOM P903.
- Nivala, M. (2009). Simple answers for complex problems: education and ICT in Finnish information society strategies. *Media, Culture & Society*, 31(3), 433-448.
- Ottestad, G. (2010). Innovative pedagogical practice with ICT in three Nordic countries—differences and similarities. *Journal of Computer Assisted Learning*, 26(6), 478-491.
- Player-Koro, C. (2012). Factors Influencing Teachers' use of ICT in Education. *Education Inquiry*, 3 (1), 93-108.
- Rogers, E. M. (2010). *Diffusion of innovations*: Free press.
- Salkind, N. J. (2012). *Statistics for People Who (Think They) Hate Statistics: Excel 2010 Edition*: SAGE Publications, Incorporated.
- Sutherland, R. Armstrong, V. Barnes, S. Brawn, R. (2004). Transforming teaching and learning: embedding ICT into everyday classroom practices. *Journal of Computer Assisted Learning*. 20(6), 413-425.
- Van Ark, B., Inklaar, R., & McGuckin, R. H. (2003). ICT and productivity in Europe and the United States Where do the differences come from? *CESifo Economic Studies*, 49(3), 295-318.

- Wigfield, A., & Eccles, J. S. (2000). Expectancy–value theory of achievement motivation. *Contemporary educational psychology*, 25(1), 68-81.
- Yusuf, M. O. (2005). Information and communication technology and education: Analysing the Nigerian national policy for information technology. *International Education Journal*, 6(3), 316-321.
- Yusuf, M. O. (2006). Problems and prospects of open and distance education in Nigeria. *Turkish Online Journal of Distance Education*, 7(1), 22-29.

Factors Affecting ICT Integration among Teachers and Students

Ying GUO

*National Research Center for School Computer Education Shanghai Branch,
East China Normal University, China
yingg@sist.ecnu.edu.cn*

Abstract: This study was conducted to determine factors that affected teachers and students ICT integration in the classrooms. There were 125 teachers who were randomly selected in elementary schools in Guangdong province of China. 283 problems faced by the teachers were studied. After further analysis of the listed problems, some pertinent issues which kept surfacing were identified. The issues include teachers concern after changing the mode of instruction to a more ICT-based is with the time distribution, the extra readings required, the new instruction model, reading using computers and remarking of students' work. On the other hand, the factor which concerned students after changing the instruction model to an integrated ICT environment was typing using the computers.

Key words: teacher, student, ICT integration, internal barriers

1. Introduction

Understanding the barriers which affected ICT integration is essential in improving the quality of education. Ertmer (1999) classified external (first-order) and internal (second-order) barriers which affected technology integration. External factors are extrinsic to teachers and include hardware and software of ICT, technical and administrative support. In contrast, internal factors are intrinsic to teachers and they include beliefs about teaching and ICT, establishing classroom practices, and willingness to change. Different barriers appeared at different phases in the integration process. Moreover, the second barriers were thought to lead to more difficulties than the first-order barriers (Dede, 1998; Fisher, Dwyer, & Yocam, 1996). Thus, even if first-order barriers were resolved, teachers would not automatically use technology to achieve meaningful outcomes.

About a hundred billion yuan RMB has been spent on ICT (Information Communication Technology) development in education in China, but it did not achieve the expected returns. Although teachers recognized the importance of using technology in their classrooms (Roblyer, 1993), numerous barriers blocked the implementation efforts (Ertmer, 1999). Knowing the barriers which are affecting ICT integration is important as the Chinese government recognized the importance of ICT integration to develop education. Most of the primary and middle schools in China equipped the computer classrooms with 30 to 50 computers at least for teaching and learning. This is in line with the external factor demand for ICT usage. So the internal factors are the main barriers for promoting the quality of education in these schools. Knowing and resolving the internal barriers which affected ICT integration is indeed crucial to achieve a high level of ICT integration and realizing the leap frog development of instructional quality.

Most of the previous studies investigated external factors which influenced ICT usage but there are only a few studies that discussed the internal factors which affected ICT integration because it is harder to tackle and measure. The internal factors discussed in this study will only include the instructional elements.

The instructional system in a class can be classified into four elements: teacher, student, media and resource. In traditional classes in China, the main instruction model is the teacher-centered model. The four elements in a teacher-centered model are as the following: teachers are the authority of instruction and will take most of the class hours to teach. Here students will listen and accept passively whatever what taught to them. They will hardly have time in the class to learn autonomously. The only instructional resource in the classes is the textbook, which the teachers will teach according to and students learned mostly from. Although there are reference books used by the

teachers and students, the content of these books are exercises edited according to the textbooks used in the classrooms. Instructional media like TV, computer, projector, and recorder although are used in the classrooms, they are mainly to assist teachers in their teaching and not to support students' learning processes.

With high levels of ICT integration, traditional educational beliefs and teacher-centered classroom practices should be changed to a more student-centered instruction (He, 2005). The four elements in a new instructional model are as the following: the proportion of teacher teaching time and student autonomous learning time in a class are about equal, students will have more time to construct their own knowledge compared to the traditional classrooms. Media are not only to assist the teachers' teaching but also to help students be autonomous learners. The teachers will teach and students will learn not only from textbooks but also other resources.

The comparison of a teacher-centered instruction model and a teacher-leading and student-centered instruction model can be seen in Table 1 (He, 2005).

Table 1: Comparison of Traditional Instruction Model and New Model

Elements Model	Teacher	Student	Media	Resource
Teacher-centered Model	Most of the time the teacher will be teaching	Hardly time to learn autonomously	For the teacher to teach	Textbook
Teacher-leading and Student-centered Model	Only part of the class hours is used to teach	About half of the class hours is used to learn on their own	For the teacher to teach and students to learn	Textbook and other resources

2. Research objectives

This study aimed to investigate factors influencing ICT integration in the classrooms. The internal factors about teachers and students were analyzed specifically. The concrete research questions addressed are as the following:

- [1] What are the factors that concern teachers in an ICT integrated classrooms?
- [2] What are the factors that concern students in an ICT integrated classrooms?

3. Research methods

3.1 Content analysis

The methodology of content analysis was used in this research. Content analysis (Krippendorff, 2004) is a research technique used to make replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use. In this study, the author analyzed the presence, meanings and relationships of key words within the answers given for classification purposes.

3.2 Data resource

Data were gathered from 125 teachers who taught Chinese subject selected randomly in the elementary schools in Guangdong province of China. They wrote the problems they had in their teaching in a piece of paper given by the researchers. Each teacher was asked to write between one to four problems and 283 problems were collected from the respondents. The researcher's gave a scenario before the teachers were given the time to write their problems. The scenario is as follows: A teacher-leading and student-centered instruction model is being used by teachers in the classes. The teachers have classes in one to one computer environment for several years. Students will do their readings and writing through computer. Not only the textbook but other resources for teaching and learning were also provided.

3.2 Data processing and analysis

First, the questions were numbered and key words were extracted from the problems. Next all the questions were classified into four categories: teacher, student, resource and media according to the key words and content of questions. Finally, sub-categories were formed from the same and similar topic of the questions among one category. The author asked all the questions twice to guarantee reliability of study. As a result, 283 questions were analyzed. The quantities of the questions about teacher, student, resource and media were 201, 69, 5 and 8 respectively. Sub-categories for “teacher” and “student” were formed. The teacher and student categories and quantities can be seen in Table 2.

Table 2: Teachers’ and Students’ Concerned Factors

Teacher Categories and Quantities			Student Categories and Quantities		
Teacher 201	Time distribution	56	Student 69	Divergence	34
	Reading teaching	40		Typing	22
	Basic skill teaching	35		Interests	9
	Instruction model	28		Preparing lessons	3
	Writing teaching	20		Eyesight	1
	Student works amending	17			
	Others	5			

4. Research Findings

4.1 The teachers concerned factors

- a. Time distribution. There were 56 problems related to time distribution which accounted for the largest proportion among all teacher factors. The teachers were most concern about the time distribution during class practice. There were two types of time distribution. One was the time distribution between the teacher teaching and the student learning. To change traditional instruction model, the most important thing was the change of teaching time. The teacher’s teaching time was the greatest proportion of the whole class time in the traditional instructional model, while the teacher’s teaching time and student’s autonomous learning time was equal approximately in the new model. The quality of instructions improved considerably in the lab schools where the teachers taught according to the new instruction model. This is because students had more time to learn autonomously not only from the teachers but also from the other resources. The other type was the time distribution between listening, speaking, reading and writing of the Chinese language. This was different compared to the traditional instructional model. Listening, speaking, reading and writing were important in traditional classes, but reading and writing of the Chinese language were more important in the new model. Children can listen and speak before they enroll for primary school, so reading and writing were emphasized in the classrooms.
- b. Teaching of reading. 40 teachers raised the issue on how to teach reading, which accounted for the second largest proportion among the problems posed by the teachers. The only source of reading materials was from the textbook in the traditional classes, unlike the new model where reading materials came from a variety of sources. There were 28 problems about extra reading. The biggest problem the teachers had about teaching of reading was how to use the extra readings except the textbook. The teachers were not clear how to deal with the relationship between the textbook and the extra readings. Teachers should teach the textbook during the class hours and students learn on their own the extra readings which are closely connected to grammar, new characters, and structure in their textbook. The other 10 problems about teaching of reading were on how to approve students’ reading skills. The other 2 problems were that students could not focus on readings because they are so used to reading hardcopies as opposed to electronic materials
- c. Basic teaching skill. The teachers had 35 problems about the basic skill teaching, Chinese

character and word teaching. It was really difficult to master Chinese character for students in the low grade, so the teaching of Chinese characters and words was the key problem for teachers. The problem could be solved by the teacher teaching the characters according to the textbook and student reading the same characters in different articles from the extra readings and writing the articles using the same characters in the new instructional model.

- d. Instruction model. There were 28 problems about the new instruction model. The traditional instructional model was a teacher-centered instruction whereas the new model was a teacher-leading and student-centered instruction model. Some teachers have yet to understand the elements and characteristics of the new model. The new model was mastered mainly from the four instructional elements: teacher, student, media and resource.
- e. Teaching of Writing. The teachers raised 20 problems regarding the teaching of writing. The questions included how to help students accumulate good characters and words, and how to improve students writing abilities. The problem could be solved by students having to write more articles and passages using the good characters and words in the new instructional model as compared to writing in the traditional instructional model.
- f. Remarking students work. There were 17 issues raised regarding the teachers inability to correct too many students' writings. The students wrote in each class on a computer in the new model, so there were many writings compared to the traditional classrooms which students wrote one composition in a week in general. The teachers mentioned that they will not have enough time to correct 30 to 40 students' work in a class plus homework. Peer correction and having parents revising the writings may be some effective ways to resolve the problem.
- g. Others. There were four problems raised on instructional objective and one regarding encouraging critical thinking.

4.2 The students concerned factors

- a. *Student divergence. There were 34 problems that the students in a class polarized which was the largest proportion among the factors about students. The students could learn more from many resources in the new instructional model compared to the traditional classes if they were good at reading and writing, but some students could not improve if they were not good at them. Helping students who have difficulty in reading and writing to improve their level of literacy was an issue the teachers had to face. Knowing the problems of each individual and able to give individualized assistance is an effective strategy to solve the polarized problem.*
- b. *Typing using computer. The teachers brought forward 22 problems on typing.*
 - I. Students in the low grade, could not type quickly. This will affect the students' writing and probably let some students lose their interests in writing. More typing classes would be an effective way to increase the students' ability to type.
 - II. Handwriting and typing. The students wrote on the computers and not by writing on the paper in each class, so the teachers were worried that students' handwriting ability would decrease. However, it was found that the students' handwriting abilities did not decrease in the lab schools because the time for handwriting practice was not reduced.
 - III. homonym Chinese characters. The students typed Chinese characters using pinyin input which lead to homonym Chinese characters. This is not advisable for students wanting to master the correct font of Chinese characters. Homonym Chinese character instruction is an essential part of Chinese instruction and the teacher should work on strengthening this aspect.
- c. Students' interests. There were nine issues raised regarding the problems in maintaining students' interests in reading and writing. The students could do more readings and writing compared to the traditional classes. The objective of literacy could not be achieved if students lose their interests in literacy. The teachers would use different methods to improve students' interests in reading and writing, for example, by using visual aids to aid understanding in the articles.
- d. Lesson planning. Three problems surfaced regarding lesson preparation. The students could read and write more in the new instructional model compared to the traditional classes. However, if the students took more time to prepare lessons before a class, students'

homework burden would be heavier.

- e. Students' eyesight. There was one problem about students' eyesight. The students took more time to read and write in the new instructional model compared to the traditional classes. The teachers were worried that it could degenerate the students' eyesight, thus poor vision. Good habits of using computer could be cultivated from the beginning to prevent poor vision.

4.3 Resource factors

There were 5 problems about the resource. The teachers complained that the existing extra reading resources did not match the textbooks closely and needed improvement. Moreover, the reading resources provided were not enough for teaching and learning in classes and the teachers did not have much time to prepare by themselves. The problem would be solved if the schools and government work hand in hand in creating and optimizing resources.

4.4 Media factors

The teachers came up with 8 problems about using the media. There was at least one technical personnel in each school to manage the ICT equipment to support instruction in the ICT environment. Although the routine environment in classes was one to one computer for several years, the problems of media usage still exist. Issues include *"the resources in the computer were not opened, and the students could not write when the internet could not be visited, and the teachers could not login the platform to amend the resources"*. Having technical professionals supporting the teachers in using the media equipment should provide some support in resolving the problem.

5. Conclusion and Discussion

The study investigated the problems which affected ICT integration in classes. The data showed that questions relating to external factors, like resource and media, were hardly mentioned and external factors were not the main barriers which affects ICT integration among the teachers.

The factors about teacher were the main element compared to the factor about student among internal factors which influence on ICT using in classes. Although the teachers accepted the new macroscopy belief and model of teacher-leading and student-centered, it is really difficult to implement practice for teachers and change classroom practice in their daily routines. This is because classroom practices were more personal and deeply ingrained (Ertmer,1999). Ritchie and Wiburg (1994) noted that *"traditional perceptions of what teaching, learning, and knowledge should look like are major limiting factors to integrating technology"*. To implement new instructional strategy, teachers should not only acquire new knowledge about it but weave this together with the demands of the curriculum, classroom management, and existing instructional skills (Dexter et al., 1999). Teachers had more critical challenges compared to the external barriers (Ertmer, 1999). Some factors about teachers mentioned above also existed in the traditional classes, for instance, Chinese characters and vocabulary teaching, reading skill, teaching of writing, instructional objectives and encouraging thinking. Some factors about teachers existed after the change of the instructional model to the ICT environment. Factors include time distribution, extra readings using the new instructional model, reading by computers and more students' work amendments. To solve these problems, proper training and guidance about practical strategies were crucial for teachers and teachers indeed need effective strategies for dealing with internal barriers.

Student was the other element among internal factors which affects ICT integration. Some factors about students mentioned above also existed in traditional classes. This includes students divergence, students' interests in reading and writing, and lesson planning. Typing was the main concern among students regarding the change from the traditional learning environment to the ICT integrated environment. As such, to solve this problem, students could practice typing during the Information Technology classes to increase their typing speed.

References

- Dede, C. (Ed.) (1998). *Learning with technology: The 1998 ASCD Yearbook*. Alexandria, VA: Association for Supervision and Curriculum Development.
- Dexter, S.L., Anderson, R.E., & Becker, F.L.J. (1999). Teachers' views of computers as catalysts for changes in their teaching practice. *Journal of Research on Computing in Education*, 31, 221-238.
- Ertmer, P. A. (1999). Addressing first- and second-order barriers to change: Strategies for technology integration. *Educational Technology Research and Development*, 47(4), 47-61.
- Fisher, C., Dwyer, D.C., & Yocam, K. (Eds.). (1996). *Education and technology: Reflections on computing in classrooms*. San Francisco, Jossey-Bass.
- He, K.H. (2005). The theory and method of deeply integrating ICT into curriculum. *E-education Research*, 1, 7-15.
- Krippendorff, K. H. (2004). *Content Analysis: An Introduction to Its Methodology*. Sage Publications, Inc.
- Ritchie, D., & Wiburg, K. (1994). Educational variables influencing technology integration. *Journal of Technology and Teacher Education*, 2(2), 143-153.
- Roblyer, M.D. (1993). Why use technology in teaching? Making a case beyond research results. *Florida Technology in Education Quarterly*, 5(4), 7-13.

The Role of Epistemic Agency and Progressive Inquiry in the Transfer of Mathematical Thinking

Chien-Sing LEE^{a*}, Tsung-Chun HO^b, Ping-Chen CHEN^c, Tak-Wai CHAN^d, K. Daniel WONG^e

^a*Faculty of Creative Industries, Universiti Tunku Abdul Rahman, Malaysia*
^b*Graduate Institute of Network Learning Technology, National Central University, Taiwan*
^c*Malaysia University of Science and Technology, Malaysia*

*ksdwong@gmail.com

Abstract: Instructional design of inquiry-based classrooms need to regard learning as dynamically flexible and adaptive with opportunities for emergent teaching and learning strategies as well as assessments. Consequently, we argue that emergent instructional design and emergent learning systems should focus on the discovery of instructional principles, instructional strategies and technologies that promote the development of inquiry, with teacher beliefs as a key design factor. We scope our study to the inculcation of Mathematical thinking because Mathematical thinking focuses on the identification of similarities among instances, leading to the development of general principles. The ability to formulate principles grows alongside learners' search for abstract problem-solving methods and mental schemata. These serve as analogy-enhancing transfer between different task situations. Consequently, in this exploratory study, we aim to help learners to learn to inquire and to reason, to be able to identify patterns, describe patterns and apply patterns to solve problems. Furthermore, we aim to identify how teacher's beliefs influence the design of teaching-learning practices. Subsequently, we suggest implications to the design of creative inquiry-oriented-based curriculum, pedagogy and technologies for the learning of Mathematical thinking.

Keywords: Transfer, Mathematical thinking, Engineering education, epistemic agency, progressive inquiry, technological scaffolds

1. Introduction

The 21st century requires dynamic flexible adaptive thinking. Hence, expectations have shifted from merely problem-solving to the inculcation of creative problem-solving. An example of such change is reflected in ABET's Engineering Criteria (1995). They indicate that Engineering education needs to address a wide scope of concerns, including environmental, political, social, international, and legal and ethical ramifications of decisions. More recently, Duderstadt's (2008) report highlights that the economic, political, social, and environmental context of engineering practice needs to be explicitly taught, in order to situate core scientific and technical courses within real-world concerns.

We argue that the aim of scientific inquiry and experimentation is to discover appropriate instructional strategies which can be used as conditions of learning. These conditions of learning can and should subsequently be applied as design factors in different contexts, and be adopted, adapted and refined through further scientific inquiry and experimentations.

Hypothetically, these conditions of learning should be relevant across all disciplines, and especially so for science-based disciplines such as Engineering. However, since this is an exploratory study, we scope our study to investigate and discover suitable curriculum, instructional strategies and technologies for the teaching of Mathematical thinking. We focus on the development of Mathematical thinking because Mathematical thinking (Schoenfeld, 1992) can help learners to develop the competency to identify, formulate, and solve problems. These competencies are crucial in the formation of abstract problem-solving methods and mental schemata. According to Schoenfeld, the latter competencies can serve to enhance analogy transfer between different task situations. Consequently, design factors or conditions of learning which can contribute positively to such analogical transfer needs to be identified or discovered.

Subsequently, we argue that conditions of learning are not independent from the beliefs that teachers and learners bring to the classroom. We further argue that beliefs are part of the key design factors underlying Chan's (2007) Humanity-based epistemology, which espouses that teaching should be caring and learning joyful. Consequently, we hypothesize that the mapping between teacher and learner beliefs can be used as design factors to discover suitable instructional strategies and technologies for the teaching of Mathematical thinking.

We also argue that to help learners proactively identify similarities among instances leading to the development of principles, we need to help learners to inquire and to reason, to be able to identify patterns, describe patterns and apply patterns to solve problems. As highlighted by Schoenfeld (1992), these metacognitive skills would enable efficient analogy-based transfers between different task situations. For such meta-cognitive methods to develop, we need to first help learners to refine their inquiry skills. Subsequently, we regard cases as instances of a general principle or combinations of principles. These cases present huge potential for emergent learning.

The inquiry approach we have adopted is based on Hakkarainen's (2003) gradual approach to inquiry, i.e., "progressive inquiry." Aimed at young learners learning science, progressive inquiry continuously guides learners to systematically generate their own research questions, develop their own intuitive working theories, generate intuitive ideas, critically evaluate these ideas, search for new scientific information, engage in progressive generation of related questions, and construct new working theories throughout the inquiry process.

In summary, our main aim is to discover appropriate instructional strategies and technologies that can help learners to develop a fuller understanding of principles through inquiry-based incremental knowledge transformation and refinement. Our research question is how do specific teacher's beliefs towards the learning of a specific Mathematical concept, i.e., addition influence the design of teaching practices? Subsequently, we suggest implications to teacher professional development on the design of inquiry-oriented curriculum, pedagogy and technologies for the learning of Mathematical and creative thinking.

2. Related work

Bruner (1986) and Thorndike (1906) agree that transfer of learning occurs when learning source and learning target share common stimulus-response elements. The theory of "identical elements", currently the most prevalent notion about transfer, highlights that what is more crucial is the identification of similarities among instances, which lead to general principles. The formulation of principles indicates transfer of learning arising from understanding. On top on this, Brown (1987) posits that meta-cognitive awareness of task features, problem structures, and solution methods is a crucial skill to develop because it makes relations between different situations cognitively *salient*.

With regards to teacher beliefs and practices, studies such as by Crawford (2007), Sandoval and Daniszewski (2004), Weinberger and Fischer (2006), Tillema and Orland-Barak (2006) and Jacobson, So, Teo, Lee, Pathak, & Lossman (2010) demonstrate that teacher beliefs and teaching practices are intertwined. Hence, changes in teachers' beliefs shape their planning decisions as well as interpretations of the curriculum. Subsequently, research methods for examining teacher practices, are based on inquiry instructional principles, with the aim of capturing specific key elements in inquiry practices.

We are adopting Song and Looi (2011)'s five principles of inquiry, i.e. working on authentic problems, encouraging diverse ideas, making progressive inquiry, providing collaborative opportunities and doing embedded assessment to assess teacher beliefs and practices. In their study, findings confirm that the teachers' enactment of different beliefs led to the design of different practices and the design of students' progressive inquiry and learning. They find that the teacher who had "innovation-oriented" beliefs is inclined to enact the lesson in patterns of inquiry-principle-based practices as well as enhance learning experiences with the use of technology. These patterns consequently positively influenced student inquiry processes and the effective use of technology affordances. We hope to discover more such innovation-oriented beliefs and practices in our current and future study as learning is dynamically flexible and adaptive with opportunities for emergent teaching and learning strategies as well as assessments.

3. Methodology

The design of our mechanism for transfer of learning is based on Perkins and Salomon's (1992) conditions for transfer, These are:

Comprehensive and diverse practice through extensive practice of the performance in a variety of contexts.

Creating mindfulness through relating new material to material learnt earlier and through relating the material to the learner's surroundings.

Active self-monitoring. Metacognitive reflection on one's thinking processes promotes transfer of skills, highlighting thinking processes.

Explicit abstraction. Abstraction emphasizes the structure of the situation. Explicit abstractions of principles from a situation foster transfer.

We interviewed an elementary school teacher who had four years of experience teaching in the school and another four years in tuition classes to better understand his beliefs about the teaching of Mathematics. The design of the interview questions was adapted from teacher perception categories in Song and Looi's (2011) study. To assess and validate our design, we asked him to try out our learning system, aimed at helping learners in grades 2-3 identify similarities across instances, leading to the development of general principles. Two types of exercises were designed and developed based on Perkins and Salomon's mechanism: pattern recognition exercises and question posing exercises formulated by student peers. Each type of exercise comprise of five levels of difficulty.

4. System design

We argue that challenges should be regarded as embedded assessment as assessment has often successfully shaped students' learning goals, strategies and motivation to be challenged and to learn. We designed and developed two types of exercises: pattern recognition exercises and question posing exercises formulated by student peers. Each type of exercise comprise of five levels of difficulty. Every successful answer will be awarded Ten Points. A brief explanation of each type of exercise is elaborated on below:

Pattern Recognition

The system will randomly generate questions where students need to add several numbers presented in a matrix format. The number of rows and columns in the matrix increase incrementally, building up complexity as the students progress. The simplest is a 2 x 2 matrix which builds up to a 6 x 11 matrix. The main objective of this exercise is to allow students to discover the patterns/principles behind addition through repeated practice. We hope that once the students are able to recognize these patterns/principles, they would be able to transfer these patterns/principles to answer all questions regardless of the level of complexity.

Question Posing

The aim of this type of problem is to help students with the most important processes in inquiry: question-driven process of understanding, formulation of theories in the search for new scientific information and generation of one's own explanations, hypotheses or conjectures and ultimately, deepening of the students' understanding of the concept.

5. Findings

5.1 Teaching beliefs

The instructor opined that what is most important in the design of curriculum is to help students to make associations among various concepts.

5.2 Teaching strategies

Instructors and students often face the following difficulties in learning Mathematics:

- Many students lacked interest in learning Mathematics. There were two possible reasons: either the students do not like Mathematics or they are too smart and thus find the curriculum boring.

However, they might face difficulty when the teacher teaches the advanced curriculum. One possible reason when faced with more advanced curriculum is that since the students are very young (grades 2-3), they often face difficulty expressing themselves and understanding expressions in Mathematical problems.

- Most students will encounter difficulties in learning the concept of addition. He noted that it would be beneficial if the instructor takes advantage of the way that of students communicate and learn because then, students are more able to accept and understand

His common practice in addressing these difficulties is first to teach based on the school curriculum framework. If the students do not understand, then he will use pictures to illustrate the method or demonstrate the steps and explain why to increase students' understanding and create a deeper impression on the why rather than the how. To him, it is very important for students to understand both why and how because if students could not understand, they would eventually lose the motivation to learn.

5.3 Working on authentic problems

He gave real-life examples in relating curriculum to real-life when students could not understand the concepts of Mathematics. For example, using changes to teach the concepts of positive and negative numbers can make students relate to real-life.

5.4 Encouraging diverse ideas

He agreed that different kinds of questions would need different problem-solving skills. As such, the design of the kinds of questions must consider the students' problem-solving and thinking processes. Furthermore, he believes that the expected type of answer should be determined by the degree of difficulty.

5.5 Making progressive inquiry

He regards challenging students with open-ended questions scaffolded by technology as beneficial. This is because these questions, especially those of the application type, can attract students' attention; crucial to motivating them to learn. He also thinks that teachers should not limit the number of times students can be allowed to answer in order to increase students' willingness to be challenged, and to increase the likelihood of obtaining a sense of accomplishment.

5.6 Providing collaborative opportunities

The teacher should first assess whether students' oral communication skills could enable them to express the concepts and their strategies adequately. Hence, the design of the kinds of questions must consider not only the students' problem-solving processes but also communication skills. For more difficult questions, the teacher can provide a longer period of time to allow students to think and then provide the answers.

6. Conclusion and implications

Prior research has indicated that changes in teachers' beliefs change their planning decisions as well as interpretations of the curriculum. The research methods employed for examining teacher practices were based on inquiry instructional principles as these help capture specific key elements in inquiry practices. Song and Looi (2011) have investigated how specific teacher beliefs impacted specific teacher practices in Mathematics and how these practices influenced the design of student inquiry learning in specific domain in a CSCL environment. Their findings highlight that the teacher who exhibited "innovation-oriented" beliefs was inclined to enact the lesson in patterns of inquiry-principle-based practices as well as enhance learning experiences with the use of technology. These patterns in turn refined student inquiry processes and the effective use of technology affordances. We are concerned with teachers' and learners' knowledge building processes and outcomes refined through their beliefs. Hence, we regard the classroom as emergent learning systems where the beliefs function as design factors argued that to help learners proactively identify similarities among instances leading to the development of principles, we need to help learners to inquire and to reason, to be able to identify patterns, describe patterns and apply patterns to solve problems. Subsequently, we investigated how specific teacher beliefs impacted the design of student inquiry learning in specific domain for a CSCL environment. Our objective was to help learners to

identify similarities among instances which would lead to the development and testing of general principles in order to improve transfer of learning, arising from understanding.

Our system is designed to help learners search for abstract problem-solving principles and methods by forming analogies between different task situations. We provided **comprehensive and diverse practice**. Two different categories of exercises, i.e. pattern recognition and question-posing exercises (fill in the blanks (self) and peer-teaching) would be randomly generated. Each contains five levels of complexity. Pattern recognition aims at affording **explicit abstraction**, while question-posing to create **mindfulness** and **active self-monitoring**. Pattern recognition is sequenced before pattern description as students need to recognize patterns in order to generalize principles. There are two levels to the question-posing exercises, i.e., fill in the blanks (self) and peer-teaching. Students need to achieve of level of mastery of 80% right for the current level before they can proceed to the next level. We hoped that students would be engaged in investigations not only in learning content but also discipline-specific reasoning skills and practices collaboratively, by constructing and testing their own mathematical models. Ultimately, we hope to make learning real - to enable learners to experience what it means to contribute to social-technological development through Mathematics and Mathematical thinking.

Our interview data show that our instructor practices principle-based inquiry. He stresses on teaching based on systems thinking in order to help learners to associate concepts and methodologies/processes. Furthermore, he emphasizes that Mathematics learning is not only about the computations but more of Mathematical thinking, i.e., teaching the *why* underlying the *what* and *how* by using different cases and strategies.

The epistemology behind our system design is congruent with his beliefs. Therefore, he accepts the system and can identify the benefits that we hoped for, i.e. to inculcate Mathematical thinking and motivation to learn further. He could also identify that we are attempting to highlight cognitive *salience* of similarities among instances be they task features, problem structures, solution methods or relations between different contexts of increasing complexity. He was thus positive regarding the potential learning outcomes if the system were to be implemented in the actual classroom.

We conclude with implications arising from this study and our future work. To foster development of big ideas and principles, a possible means that can be explored is Lee's (2012b) suggestion that teachers be trained to teach based on pedagogical schema and ontological connections. Focusing training on these two factors is likely to help teachers determine identify topical and pedagogical similarity. This may result in more effective ontological mapping and experimentation in the adoption, adaptation and scaling of teaching-learning strategies.

To inculcate creative teaching-learning approaches, Lee (2012a) suggests that we should provide for variations in teaching-learning strategies among behaviorist-cognitivist-constructivist approaches to enhance learning experiences. The choice of approach depends on the learning needs and the instructor's beliefs. She suggests regarding learning approaches as testbeds for variable experimentation along three dimensions, i.e., creative types (exploratory creativity, combinatory creativity and adaptive creativity), creative processes and learning approach. Lee (2012b) further suggests that teachers be trained to teach based on pedagogical schema and ontological connections. She hypothesizes that the ability to identify topical and pedagogical similarity may result in more effective ontological mapping, foster development of big ideas and principles, and experimentation in the adoption, adaptation and scaling of teaching-learning strategies.

Furthermore, consistent with inquiry-based epistemology, experiments are regarded as the essence of meaningful and fun teaching and learning. Hence, we suggest regarding learning approaches as testbeds for variable experimentation along three dimensions, i.e., creative types (exploratory creativity, combinatory creativity and adaptive creativity), creative processes and learning approach. Beginning with the design of technology-mediated learning activities and content along these three dimensions will create a viable testbed. From this study, we add that open-ended challenges should be regarded as embedded assessment. These preliminary findings will help us will design and experiment with different instructional strategies in our future work.

Acknowledgment

We wish to thank Taiwan's National Science Council for research grant NSC100-2511-S-008-020-MY3. The study was conducted while the first author was a Faculty at National Central University, Taiwan.

References

- ABET. (1995). *The Vision for Change: A Summary Report of the ABET/ NSF/ Industry Workshops*, Accreditation Board for Engineering and Technology.
- Bruner, J. (1973). *Going Beyond the Information Given*. New York: Norton.
- Chan, T.W. (2007). Humanity-Based Classroom: Teaching is Caring and Learning is Joyful," In L. Rosemary, R.K. Kenneth and G. Jim, *Artificial Intelligence in Education*. [keynote speech]
- Crawford, B.A. (2007). Learning to teach science as inquiry in the rough and tumble of practice," *Journal of Research in Science Teaching*, 44 (4), 613-642.
- Duderstadt, J.J. (1995). *Engineering for a Changing World: A Roadmap to the Future of Engineering Practice, Research, and Education*, University of Michigan.
- Hakkarainen, K. (2003). Progressive Inquiry in a computer-supported biology class," *Journal of Research in Science Teaching*, 40 (10), 1072-1088.
- Jacobson, M.J., So, H. J., Teo, T., Lee, J., Pathak, S. and Lossman, H. (2010). Epistemology and learning: Impact on pedagogical practices and technology use in Singapore schools," *Computers & Education*, 55 (4), 1694-1706.
- Lee, C. S. (2012a). Inculcating creative use of technology to enrich learning. *Global Chinese Conference on Computers in Education*, May 28-June 1, 2012, Kenting, Taiwan.
- Lee, C. S. (2012b). Reuse of Pedagogical Strategies Across Different Mathematics Topics based on Ontological and Pedagogical Schema. *Global Chinese Conference on Computers in Education*, May 28-June 1, 2012, Kenting, Taiwan.
- Merrill, M. D., Drake, L., Lacy, M. J., Pratt, J., & ID2_Research_Group. (1996). "Reclaiming instructional design," *Educational Technology*, 36(5), 5-7. <http://mdavidmerrill.com/Papers/Reclaiming.PD>
- Perkins, D.N. and Salomon, G. (1992). Transfer of learning. *International Encyclopedia of Education* (2nd ed.). Oxford, UK: Pergamon Press.
- Sandoval, W. A. & Daniszewski, K. (2004). Mapping trade-offs in teachers' integration of technology-supported inquiry in high school science classes. *Journal of Science Education and Technology*, 13 (2), 161-178.
- Schoenfeld, A.H. (1992). Learning to think mathematically: Problem-solving, metacognition and sense making in Mathematics. In D. Grouws (Ed.), *Handbook for Research on Mathematics Teaching and Learning*. New York: MacMillan, 334-370.
- Song, Y. J. & Looi, C.K. (2011). Linking teacher beliefs, practices and student inquiry learning in a CSCL environment: A tale of two teachers. *Computer-Supported Collaborative Learning*, 7 (1), 129-159.
- Tillema, H. and Orland-Barak, L. (2006). Constructing knowledge in professional conversations: The role of beliefs on knowledge and knowing. *Learning and Instruction*, 166, 592-608.
- Weinberger, A., and Fischer, F. (2006). A framework to analyze argumentative knowledge construction in computer-supported collaborative learning. *Computers in Education*, 46 (1), 71-95.

Developing Learning System in Pesantren: The Role of ICT

Syaiful ROHIM^{a*} & Lina YULINDA^{a**}

^{a*}University of Muhammadiyah Prof. DR. HAMKA (UHAMKA), Indonesia

^{a**}Bakti Mulya Senior High School, Indonesia

^{*}aimmacan@gmail.com; ^{**}yulindalina@yahoo.co.id

Abstract: The development of information and communication technology has led to many changes, including in the field of education which is established the concept of e-learning. By using e-learning, learning is become more effective and efficient. Information and communication technology is also used in schools, it is possible to produce the concept of e-pesantren. Through the use of ICT, religion teachers and students at the school could be preaching, teaching and learning with greater ease, and the teaching models e-pesantren is also very useful, both for students and teachers (religion teacher), even for the managers of pesantren, of which is increasing prestige and institutional accountability. E-pesantren allows creating a system of distance education and virtual school / boarding. The integration of information and communication technology in education in schools is to improve the quality of education in schools and ease of propagation.

Keyword: *E-Pesantren, E-Learning, santri, ustadz*

1. Introduction

In a report from Wingspread Group on Higher Education in 1993, it was written: "The nation that responds best and most rapidly to the educational demands of the Age of learner will enjoy a commanding international advantage in the pursuit of both domestic tranquility and economic prosperity, this will require new ways of thinking". This quote shows that there is a learning era which is requires making a new way of thinking in education. Some students respond better to visual and audio stimuli of lecture but often get lost in the material or lose interest in the presentation. In this type of a learning environment, students have limited opportunity to ask questions or may be uncomfortable asking a question in front of the class. It is well known that many questions go unasked. It is widely recognized that learners are motivated and purposefully engaged in the learning process when concepts and skills are underpinned with technology and sound pedagogy. Learning and Teaching Scotland aims to provide resources for practitioners, parents and pupils to engage with these technologies in order to inform and enhance the learning experience.

We are now living in a constantly evolving digital world. ICT has an impact on nearly every aspect of our lives - from working to socializing, learning to playing. The digital age has transformed the way young people communicate, network, seek help, access information and learn. We must recognize that young people are now an online population and access is through a variety of means such as computers, TV and mobile phones. As technology becomes more and more embedded in our culture, we must provide our learners with relevant and contemporary experiences that allow them to successfully engage with technology and prepare them for life after school.

The development of Information and Communication Technology (ICT) has urged people to develop the efficiency and the effectiveness in every activities. All sectors such as e-commerce, e-banking, e-government has used the ICT in their activities. We just entered 21st century, there are a lot of education institution, especially from the other country which is trying to develop their learning quality by using ICT through E-Learning Program. In Malaysia, the program of E-Learning gets full support from the government through the Agenda, Information Technology National Program whis is established by National Information Technology Council (NITC). NITC wants to make Malaysia ready to compete in globalization era, so they make five agenda, E-Community, E-Public Services, E-Learning, E-Economy, and E-Sovereignty (Koran, 2003). In Singapore ICT is more progress in the era of E-Government with the vision to be leading E-Government to better serve the nation in the digital economy (Djunaedi, 2003)

Although the infrastructure of ICT in Indonesia is still lower than the other countries, it will be better if all the people that work in education sector, which are include the teachers (ustadz) and the manager of

pesantren have to try to think and act to increase the function of *dakwah* and education by using the ICT. If it doesn't start from now, it is very possible that *Pesantren* in Indonesia and all the community inside become the community that left behind by the technology.

2. Learning and ICT

Learning is the interaction between what students know, the new information they encounter, and the activities they engage in as they learn. Students construct their own understanding through experience, interactions with content and others, and reflection. Learning style theory proposes that individuals learn in different ways, that there are four distinct learning styles feeling, watching, thinking and doing, and that knowledge of a learner's preferred learning style will lead to faster and more satisfactory improvement.

Learning is seen more and more as an active individual process, where learners construct their own knowledge base. Learning is also increasingly seen as a process based on sharing and the purpose is not to transfer knowledge but to create environments and experiences that bring students to discover and construct knowledge for themselves, to make students members of communities of learners that make discoveries and solve problems, and recognizing that the chief agent in the process is the learner.

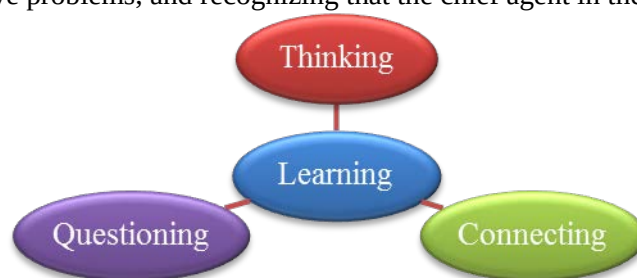


Figure 1 The process of learning

Stands for "Information and Communication Technologies." ICT refers to technologies that provide access to information through telecommunications. It is similar to Information Technology (IT), but focuses primarily on communication technologies. This includes the Internet, wireless networks, cell phones, and other communication mediums. ICT are often spoken of in a particular context, such as ICTs in education, health care, or libraries.

Since the demand for telephone and internet communication services in all segments of society is increasing, make people more easily and quickly communicate with the outside world and facilitate in finding existing information by using the internet. Nowadays internet access is no longer monopolized by cable or by satellite phone. The current internet access easily can be done by using cellular technology such as GSM technology (Global System Mobile) and CDMA (Code Division Multiple access), even for difficult areas internet can be acces directly via satellite.

Background of the development and the use of Information and Communication Technology (ICT) has penetrated and coloring all sides of public life, including education. In everyday life the use of information and communication technologies by today's society has become commonplace, no longer become a dream that difficult to realize, including the beneficial in education. Learning via the Internet (e-learning) with multi-media computers are widely known and utilized by the education community, even this has become a necessity for all the information and educational development can be delivered quickly and accurately. In the cities, the students start from elementary school level (SD) to university is used to access the internet to search for material enrichment lessons that acquired in school. Subject matters who have not understood at school or who have not received at school can be easily searched and obtained via the Internet.

The main purpose of ICT in Education means to implement of ICT Equipments and Tools in Teaching-Learning process as a media and methodology. The purpose of ICT in education is generally to familiarize students with the use and workings of computers, and related social and ethical issues. ICT has also enabled learning through multiple intelligence as ICT has introduced learning through simulation games; this enables active learning through all senses. Information and communication technologies (ICT) which include radio and television, as well as newer digital technologies such as computers and the Internet, have been touted as potentially powerful enabling tools for educational change and reform. When used appropriately, different ICT are said to help expand access to education,

strengthen the relevance of education to the increasingly digital workplace, and raise educational quality by, among others, helping make teaching and learning into an engaging, active process connected to real life.

According to C. Paul, ICT can Investigate reality and build knowledge, for example ICT allows students to investigate more thoroughly the real world using up-to-date information and tools to build a broader and deeper knowledge. Students also can collect and analyze data using ICT probes to investigate water salinity problems in a local river. ICT also can Promote active learning and authentic assessment, for example ICT may be used to support students in being more active as participants in their own learning and learn by doing rather than just listening or reading. Students create a digital video of a school camp to communicate what they valued. Students use a simulated environment to consider building a town. Students interact with children from another country to create a play. ICT provide tools to increase student productivity, the activity such as students construct multiple graphically representations of data collected from a survey. Students use a spreadsheet to calculate the costs associated with installing a reticulation system and use the results to successively improve their own designs (Paul Newhouse, 2002).

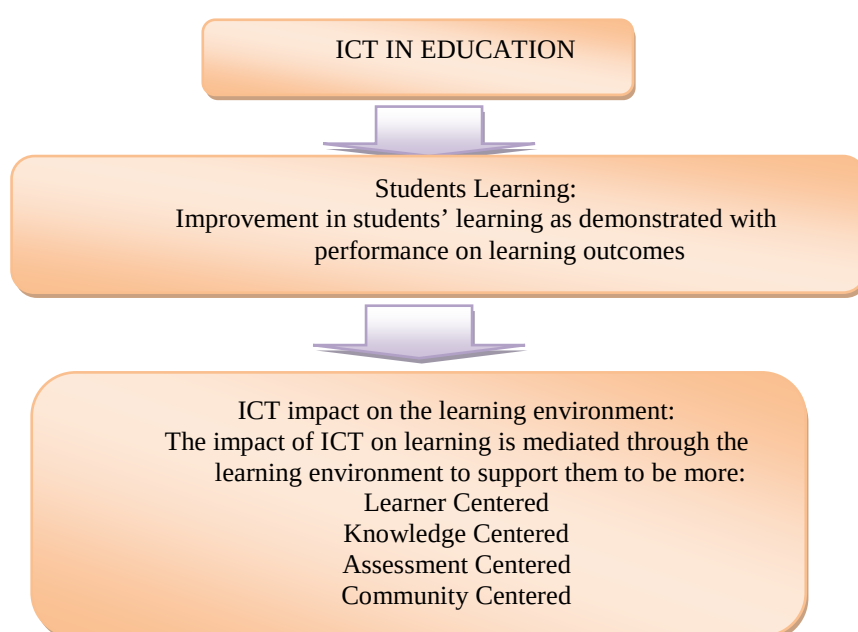


Figure 2 The impact of ICT(Paul Newhouse, 2002)

The power of ICT also urges the changing in curriculum, which is include the changing of the purpose and the content, learning activities, tes and scoring, learning final result, and positive additional score. That's why nowadays there are so many terms that appear such as E-Teacher, E-Test, E-Library, E-assignment, E-Education, Virtual School, Virtual University, E-Learning, and etc. E-Learning is a learning which is using ICT to transform the process of learning between the teacher and the student. The main purpose of the using of this technology is to increase the effeciency and effectivity, transparency, and learning accuntability.

From those explanation, it is clear that E-Learning is using ICT as a tool, with the main purpose is to increase the effeciency and effectivity, transparency, accuntability and comfortable learning, which is the object is the learning service become better, interesting, interactive, and attractive. The final result is expected there will be the increasing of achievement, students' academic mastery, and also cost less and time for learning process.

E-Learning is a learning model based on the students' center. By using E-Learning students expected become more individual and more responsible in learning process, because students can learn in anytime and anywhere, the most important is the instrument is available. E-Learning is demanding the students to be more active. Through E-Learning, students can find information/learning material based on the syllabus/criteria that is already stated by the teacher. Students will have a lot of information, because the students can access all information from anywhere which is related with the

learning material. Students also can do on line discussion with all experts, for example by sending e-mail or chatting. It is clear that active students in E-Learning is absolutely determine their final result.

E-Learning is also gives a chance to all students to study without any underpreasure. It means that the students are free to find their own learning material. Students also free from feeling of ashamed, that usually happens in traditional class, if the students can't answer teacher's questions, or failed in their learning. The students can be free ask some questions and make discussion with the experts or through professional help program by on line which is design in E-Learning material. Students also can repeat all the material until the material is mastered. Meanwhile, for the students who "fast" in learning, they can learn the next topic without waiting the "lower" students. By doing this system, it is expected that the result of the final learning will be better by using the E-Learning, because the mastery learning will be reach. Students also free to acces the E-Learning material from anywhere.

E-Learning material that create well and professional will use the characteristic of multimedia. It means that, the learning material should include text, picture, grafic, animation, simulation, audio and video. The choosing of the right color is also can create interesting display in the monitor. This things can make the learning material become more interesting, interactive, and attractive. Because of this situation, it can make students want to learn more and become more curious. E-Learning also can be design to save the students' achievement record, which can be useful for feed back process. This record can be used to reinforcement. Beside that, E-Learning also can be design to check the test and to give score automatically, so that the element of transparency and accuntability can be fullfilled in this process. Based on this evaluation result, students automatically suggested to do certain learning activities. (Pribadi dan Rosita, 2003).

Table 1: The advantages and disadvantages in using ICT

Advantages	Disadvantages
• Through ICT, images can easily be used in teaching and improving the retentive memory of students. • Through ICT, teachers can easily explain complex instructions and ensure students' comprehension. • Through ICT, teachers are able to create interactive classes and make the lessons more enjoyable	• Setting up the devices can be very troublesome. • Too expensive to afford • Hard for teachers to use with a lack of experience using ICT tools

3. ICT and Pesantren (Boarding school for moslem)

The increasing of ICT has made creative persons to bring about and develop their creative idea effectively and efficiently. Nowadays there are some young people who might be don't have real *Pesantren*, try to make electronic pesantren (E-Pesantren), such as Indigo Pesantren and Virtual Pesantren. The basic idea of Virtual Pesantren is the effort to develop Islam idea with all the discourses. The establish of Virtual Pesantren is the answer that we need to develop Pesantren Education System especially in digital and information era. Virtual Pesantren is a proof that Pesantren system also can join the information era with the color and the mission doesn't change with convensional Pesantren.

In E-Pesantren, for example on <http://pesantrenvirtual.com/>, there are some programs that still the same as convensional Pesantren. Such as Ustadz (teacher) Consulting, Dhikr and pray, wisdom, Consultation, Question and Answer, Fiqh, and the studies of Islam. This is shown that by using ICT, magnificence of Islam from Ustadz (teacher) and Santri (students) can be developed. They will not find any difficulties because the media is getting easiest. The characteristics of E-Pesantren is very useful for all Ustadz and Santri, even all the managers of Pesantren. E-Pesantren make the distance learning become more easier. For all santri (students), it is clear that E-Pesantren can train and increase the individuality of santri (students). Moreover, it also can give the easiest way for all santri to access all

the material wherever they are, more economical, and the important is all santri can learn without any embarrassment feeling if they are lower than the other santri.

These are the benefits that can be achieved by Santri in using E-Pesantren, such as can develop the interaction when santri is doing some on line discussion, accomodate the differences in santri, santri can repeat all difficult materials for many times until santri can mastered the material, easiest access, santri can study without any underpreasure, free to ask anything in on line, decrease the cost, force santri to browse all information in world wide web, santri can choose the target and the material that appropriate in website, develop the ability in using the internet and force santri to have responsibility in their learning and develop their self-knowledge and self-confidence.

The benefit of E-Pesantren also can be felt by the Ustadz (teacher). For example Ustadz can give materials and problems which is up to date to be studied by the santri (student), easy to access anything in every situation and condition, decrease the cost of accomodation in training program, and also can communicate their ideas in wider area.

The development of ICT can be very useful for pesantren. Pesantren is a learning community, that's why pesantren can use ICT to expand the society education. It also can improve and increase the quality of formal education. These things are very possible to be done because the human resources are already complete. It means, there are Kyai and Ustadz, santri who are already use to do anything by themselves, there is interaction media, education facilities, and management of pesantren. In the real world pesantren is already goes well, that's why it is very possible to bring "real" pesantren to the electronic pesantren.

4. The Preparation of The Using of ICT in Pesantren

From the explanation above, in order to expand the "real" pesantren to E-Pesantren, there are some preparation that should be filled, such as infrastructure, human resources, and the learning material. From the infrastructure, we need the available of computers, LCD Proyektor, Computer Network, Internet Connection, homepage of all Kyai and Ustadz, and E-Library. In general the availability of ICT infrastructure in Indonesia is still low. Penetration Computer (PC) IN Indonesia is only about 4%, than in Malaysian and Australia which is can reach until 80% (Koran Tempo, 18 February 2008).

Our spirit should not be down because of those condition, in the future the supplying of Information Technology is become cheaper. It is very possible that someday pesantren can fullfilled their hardware needs in information technology. From the side of communication technology (include the internet connection), in Indonesia is still more expensive than the other countries. That's why we hope there is some regulations from the government (Minister of Information and Communication) who can decrease the cost of internet connection, so can increase the connection from computer to the internet. The existence of Warnet (Warung Internet) also can be said as the support of infrastructure that can be used to start the E-Pesantren.

The preparation of the human resources (ustadz and santri), in using ICT they must understand about Computer. The literacy of computer is absolutely different, it depends on the role and the responsibility. The computer literacy is a term that usually used to explain the basic knowledge of computer. *Konsep literasi komputer lebih berkaitan dengan segi praktis penggunaan komputer, bukan perancangan dan pengembangan komputer itu sendiri* (Sugilar, 2005). The computer literacy concept is more related with the practical of the using of computer, not about the planning and the developing of the computer itself.

As the term of the development of learning program, computer literacy refers to the operation of aplication program, the social context in the using of computer, the understanding about what is computer and how does it works, the history of computer, and practical knowledge, at least one of the highest program in computer. Computer literacy also can be seen from what things that has been done by someone that related with computer, such as the time length in using computer, the using of computer program, and the skill in making computer program.

From those explanation above, we can say that the main qualification to do E-Pesantren are learning activity is done by using the computer network, the availability of learning service that can be used by all santri, such as CD ROM, and the last is the availability of tutor service. Beside of that the role of Kyai and Ustadz can't be changed all by technology. It means that in implementing, the role of E-Pesantren is as a supplemen. For example Kyai and Ustadz as a good model for moslem.

There are so many kinds of pesantren in Indonesia based on the condition, so the level of the infrastructure's availability and the human resources is different. That's why the steps of developing ICT can be categorized in emerging, applying, infusing, and transforming fase, (Majumdar, 2005). Emerging is the step where all the educator gives more attention to ICT. Applying is the step where all educators start to learn by using ICT. Infusing is the step where all the educators start to know how and when the ICT is used. The last step is transforming, in specific can use ICT to help the finishing of all works in learning and managing the education.

The using of ICT in pesantren gives a wide impact. If an Ustadz can use ICT in learning system, it will also gives impact to all santri. This condition can make all santri are using ICT. So that all the Indonesian people can become computer literacy. That's why it is very important for pesantren to give ICT skill in learning for all santri.

5. Closing

The power of ICT has made a lot of changing in learning. Institutions outside of pesantren, has tried to do their learning process bu using ICT. It means that the virtual college concept is about to entered by them. So that they can reach the target without any obstacles. This condition can cause education become cheaper and interesting. The using of ICT in learning gives a lot of advantages for santri, ustadz and the manager of pesantren. The use of ICT can increase the efficiency and the effectivity in learning process and pesantrens' manager. Beside that, ICT will expand and increase the society education, especially for moslem. Eventhough the infrastructure in implementing E-Pesantren is still low, the E-Pesantren concept should be introduce to all santri. It is must be done to make santri doesn't left behind in the development of ICT.

Acknowledgements

We would like to thankful for all the people that support this paper. We hope that this paper can give a great contribution especially in Information, Communication and technology for education.

Authors

SYAIFUL ROHIM is a senior researcher from University of Muhammadiyah Prof. Dr. Hamka (UHAMKA) Indonesia, Doctoral of Political and Communication.

LINA YULINDA is an English teacher from Bakti Mulya Senior High School with a lot of experience in teaching by using ICT

Reference

- Budi Raharjo (2001), *"Internet dan Pendidikan"* (TAK LENGKAP)
- Djunaedi, A. (2003), *"Beberapa Pemikiran Penerapan E-Government dalam Pemerintah Daerah di Indonesia"*. makalah dalam Seminar Nasional E-government di FMIPA UGM Yogyakarta, 30 Oktober 2003.
- Dhofier, Zamakhsyari (1982), *"Tradisi Pesantren: Studi tentang Pandangan Hidup Kiai"*. Jakarta: LP3ES
- Koran, J.K.C. (2003), *"Aplikasi E-Learning dalam Pengajaran dan Pembelajaran di Sekolah-sekolah Malaysia : Cadangan Pelaksanaan pada Senario Masa Kini"*. Koran Tempo, 18 Januari 2008.
- Majumdar, S. (ed). (2005), *Regional Guidelines for Teacher Development for Pedagogy Technology Integeration*, Bangkok : UNESCO.
- Pribadi, P.A., dan Rosita, T. (2003), *Prospek Komputer sebagai Media Pembelajaran Interaktif dalam Sistem Pendidikan Jarak Jauh di Indonesia*. On line : <http://202.159.18.43/jsi/82benny.htm> tanggal 10 Februari 2003.
- Republika, 25 Februari 2008. Sahal, Mahfud, Dr. KHMA, *"Pesantren Mencari Makna"*, Lkis, Yogyakarta
- Sugilar. (2005), *Hubungan Literasi Komputer Dengan Sikap Terhadap Pembelajaran Berbantuan Komputer*, 2005, On line : <http://www1.bpkpenabur.or.id/jelajah/02/sosial.htm> tanggal 20 Februari 2005.
- Yuk, V. (2006), *"ICT in Instruction (e-learning) & The Power of ICT"* "paper in Training Programme ICT for Quality Improvement of Graduate Study" organized by SEAMOLEC, ITB, DGHE MONE, Bandung, 23 – 27 June.
- Wingspread Group on Higher Education. (1993), *An American Imperative: Higher Expectations for Higher Education*. The Johnson Foundation, Inc, 1993
- www.Pesantrenonline.com
- www.kompas.co.id

Exploring the Changes in In-service Teachers' Perceptions of Technological Pedagogical Content Knowledge and Efficacy for ICT Design Thinking

Ching Sing CHAI^{a*}, Joyce Hwee Ling KOH^a, Pei-Shan TSAI^a, Normalah ISMAIL^b & Erwin ROHMAN^b

^a*National Institute of Education, Nanyang Technological University, Singapore*

^b*Nan Chiau Primary School, Singapore*

*chingsing.chai@nie.edu.sg

Abstract: The present study explores the changes in teachers' perceptions of technological pedagogical content knowledge (TPACK), and their efficacy for ICT design thinking. The TPACK survey and the Technological Pedagogical Content Design survey (TPCD) were administered to 100 Singaporean in-service teachers who participated in a three-day professional development session for ICT mentors. The TPACK-MLS has seven scales, including content knowledge (CK), pedagogical knowledge (PK), Pedagogical content knowledge (PCK), technological knowledge (TK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPACK). The TPCD has two scales, including design practice (DP), and design disposition (DD). The results shows that through the workshop activities, the teachers had significant positive change in their perceptions of pedagogical knowledge (PK), technological knowledge (TK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), technological pedagogical content knowledge (TPACK). The professional development sessions also enhanced the teachers' perception about their design practice (DP) and design disposition (DD).

Keywords: Technological pedagogical content knowledge (TPACK), design thinking, design practice, design disposition

1. Introduction

The technological pedagogical content knowledge (TPACK) framework (Mishra & Koehler, 2006) has been utilized in many studies to explore the teachers' knowledge for the integration of information and communications technology (ICT). For example, Schmidt, Baran, Thompson, Mishra, Koehler, and Shin (2009) have employed this framework to explore pre-service teachers' knowledge about pedagogy, content, and technology. The TPACK framework has seven components, comprising three main knowledge sources (i.e. content knowledge, pedagogical knowledge, technological knowledge) and four advanced components that are derived from the interactions among these three basic knowledge sources (i.e. pedagogical content knowledge, technological pedagogical knowledge, technological content knowledge, and technological pedagogical content knowledge).

Recently, many surveys based on the TPACK framework to explore teachers' self-efficacy about TPACK. Examples of such studies are Asian pre-service teachers' perceptions of technological pedagogical content knowledge (Chai, Ng, Li, Hong, Koh, 2013), K-12 online teachers' TPACK (Archambault, & Crippen, 2009), and teachers' perception about the integration of web-based resources (Lee & Tsai, 2010). These surveys provide educators a way to explore the factors influencing teachers' integration of ICT and to measure if the teachers' efficacies have improved after professional development activities.

More recently, Chai, Koh, and Tsai (2013) theorized that teachers' general efficacies for design practices (DP) and their design disposition (DD) are associated with teachers' TPACK efficacy and

therefore could influence teachers' TPACK development. Teachers' general efficacy for DP is related to how teachers deal with design problems while their DD is related to their propensity to engage in the resolution of design problems. That is, teachers' confidence for engaging in ICT design thinking may influence how they enact their TPACK in ICT-based classrooms. Koh, Chai, Hong, and Tsai (2013) developed the Technological Pedagogical Content Design survey (TPCD) to investigate the relationship between teachers' perceptions of TPACK, DP and DD. They found that these constructs are significantly correlated. Hence, the enhancements of teachers' perceptions of TPACK could also change teachers design practice and design disposition. As current literature has not discussed how teachers' design practice and disposition could be enhanced, this study attempts to contribute to TPACK research by investigating these new factors associated with teachers' TPACK development.

Many studies indicated that the effective of professional development course can support teachers to improve their TPACK perceptions (Lee, Chai, & Koh, 2012; Nadelson, Callahan, Pyke, Hay, Dance, & Pfiester, 2013). For example, Lee et al. (2012) found that the effectiveness of an ICT course can support teachers to improve their technology-related ability more than non technology-related ability. Thus, this study attempts to examine the impact of a professional development activity for Singapore teachers' changes in TPACK, DP and DD. Our research question is: Were there any changes in the teachers' perceptions of TPACK, design practices and design disposition after the professional development activity for ICT mentors?

2. Method

2.1 Participants and Program

The participants of this study were 100 in-service teachers (including 34 males and 66 females). Their average teaching experience is 6.40 years. All of them were enrolled in the ICT mentors' program which is conducted by an educational institution in Singapore to develop teachers who can serve as mentors of ICT initiatives in Singapore schools. The program pedagogy emphasizes teacher engagement in design work. Throughout the three days, teachers worked in groups according to their content specialization to critique ICT lesson plans, explore ICT tools for supporting 21st century learning, design ICT lesson ideas to support 21st century learning, as well as to engage in peer critique and refinement of these lesson ideas. The survey was conducted before and after the workshop to explore the changes in teachers' perceptions about content knowledge, knowledge about teaching methods, knowledge about technology integration and design efficacy. Participation was voluntary.

2.2 Instrument and procedure

The TPACK survey developed by Chai et al. (2013) was adopted in this study to explore teachers' perceptions about content knowledge, knowledge about teaching methods, and knowledge about technology integration. The TPACK survey consisted of seven scales, including content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), technological knowledge (TK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPACK). According to Chai et al. (2013), the survey had been verified by both exploratory factor analysis and confirmatory factor analysis, indicating the survey had acceptable reliability and validity. The definition of each TPACK scale is as follows:

- Content knowledge (CK): Teachers' knowledge of subject matter, e.g., I can think about the content of my main teaching subject like a subject matter expert.
- Pedagogical knowledge (PK): Teachers' knowledge of teaching methods, e.g., I am able to help my students to reflect on their learning strategies.
- Pedagogical content knowledge (PCK): Teachers' knowledge of teaching methods with respect to subject matter content, e.g., Without using technology, I can help my students to understand the content knowledge of my main teaching subject through various ways.
- Technological knowledge (TK): Teachers' knowledge of technology tools, e.g., I know how to solve my own technical problems when using technology.

- Technological pedagogical knowledge (TPK): Teachers' knowledge of using technology to implement teaching methods, e.g., I am able to facilitate my students to collaborate with each other using technology.
- Technological content knowledge (TCK): Teachers' knowledge of subject matter representation with technology, e.g., I can use appropriate technologies (e.g. multimedia resources, simulation) to represent the content of my main teaching subject.
- Technological pedagogical content knowledge (TPACK): Teachers' knowledge of integrating technology to teach in specific pedagogical approach for specific subject matter, e.g., I can formulate in-depth discussion topics about the content knowledge and facilitate students' online collaboration with appropriate tools. (e.g. Google Sites, CoveritLive).

The Technological Pedagogical Content Design survey (TPCD) developed by Koh et al.'s (2013) was also implemented in this study to investigate these aspects of teachers' design efficacy. The TPCD consisted of two scales, including design practice (DP), and design disposition (DD). According to Koh et al. (2013), the TPCD items were verified by exploratory factor analysis, and the survey had acceptable reliability and validity. The definition of each TPCD scale is as below:

- Design practice (DP): How teachers deal with design problems, e.g., When designing an ICT lesson, I allow conflicting lesson ideas to coexist until I feel that I have adequately understood the learning problems.
- Design disposition (DD): Teachers' propensity to engage in the resolution of design problems, e.g., I am comfortable to deviate from established practices.

In order to explore the changes of teachers' perceptions of TPACK and design efficacy before and after the professional development activity, the participants were asked to indicate their agreement with these two online surveys before and after the activity. Their responses were scored by using a 7-point Likert scale (i.e. 1 for strongly disagree and 7 for strongly agree). The reliability coefficients of the teachers' perceptions before activity were from 0.90 to 0.96, and those of the teachers' perceptions after activity were from 0.95 to 0.98, indicating that the TPACK and TPCD surveys had satisfactory reliability to measure teachers' view of content knowledge, knowledge about teaching methods, knowledge about technology integration, and design efficacy. This study further utilized paired-samples *t* tests to find out the changes of teachers' perceptions before and after the activity.

3. Results

Table 1 shows the teachers' average scores and standard deviations on the seven scales for each of the pre-test and post-test of the TPACK and on the two scales for each of those of the TPCD. The results of paired-samples *t*-tests are also shown in Table 1. Except for the scales of content knowledge (CK) and pedagogical content knowledge (PCK), there were significant differences found for the other seven scales. For the scales of pedagogical knowledge (PK), technological knowledge (TK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), technological pedagogical content knowledge (TPACK), design practice (DP), design disposition (DD), the teachers' scores after the professional development program were significantly higher than those before the activity. It implies that through the design activities they participated in, the teachers held stronger self-efficacy perceptions of pedagogical knowledge (PK), technological knowledge (TK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), technological pedagogical content knowledge (TPACK), design practice (DP), and design disposition (DD). Notably, the increase in ratings TPK, TCK, TPACK, and DP were the largest.

Table 1: Descriptive data and results of paired-samples *t*-test.

Surveys	Factors	Pre-test		Post-test		<i>t</i> -value
		Mean	SD	Mean	SD	
TPACK	CK	5.75	0.74	5.79	0.84	0.77
	PK	5.36	0.77	5.58	0.84	3.58**

	PCK	5.21	1.05	5.24	1.07	0.42
	TK	5.17	1.10	5.52	1.01	4.78***
	TPK	4.74	1.13	5.53	0.91	8.11***
	TCK	4.75	1.12	5.48	0.97	8.15***
	TPACK	4.34	1.20	5.35	0.86	9.23***
TPCD	DP	5.07	0.98	5.64	0.92	6.43***
	DD	5.33	0.98	5.62	0.94	3.89***

** $p < 0.01$; *** $p < 0.001$

4. Discussion and conclusions

TPACK is a kind of knowledge that emerges through design activities (Koehler, Mishra, & Yahya, 2007), Teachers' capacity for design is inextricably linked with their capacities for fostering TPACK. This study examines the impact of a professional development activity on changes in teachers' perceptions of technological pedagogical content knowledge (TPACK), and their efficacy for ICT design thinking. The results revealed that through activity design-intensive pedagogy and multiple design opportunities, the teachers held stronger perceptions of pedagogical knowledge (PK), technological knowledge (TK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPACK). Similar findings are shown in the study of Lee et al. (2012) that the effectiveness of an ICT course can support teachers to improve perceptions of their technology-related ability more than non-technology-related ability. With regards to design practice (DP), and design disposition (DD), the results suggest that teachers' design practice and disposition can be developed along with their TPACK through design activities. Professional developments in these areas are important because they attest to the teachers' capacities to deal with emerging technologies. The more comfortable teachers are when they are confronted with emerging technologies, the more likely they are to engage in productive design activities to create new forms of TPACK. On the other hand, if teachers are apprehensive about the design problems posed by emerging technologies and shy away from design activities, their professional development will be hampered. Future research is suggested to explore how the teachers' self-reported professional developments can be further supported by their performances in addressing design problems. This can be achieved through analyzing and scoring the designed artifacts (lesson plans or lesson packages).

References

- Archambault, L., & Crippen, K. (2009). Examining TPACK among K-12 online distance educators in the United States. *Contemporary Issues in Technology and Teacher Education*, 9(1). Retrieved from <http://www.citejournal.org/vol9/iss1/general/article2.cfm>
- Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2013). A Review of Technological Pedagogical Content Knowledge. *Education Technology and Society*, 16(2), 31-51.
- Chai, C. S., Ng, E. M. W., Li, W., Hong, H. Y., & Koh, J. H. L. (2013). Validating and modeling technological pedagogical content knowledge framework among Asian Preservice teachers. *Australasian Journal of Educational Technology*, 29(1), 41-53.
- Koh, J. H. L., Chai, C. S., Hong, H. Y., & Tsai, C. C. (2013). Exploring the relationship between pre-service teachers' perceptions of efficacy for technological pedagogical content knowledge and efficacy for ICT design thinking. *Paper presented at the AECT International Conference on the Frontier in e-Learning Research 2013*, Taichung, Taiwan.
- Koehler, M. J., Mishra, P., & Yahya, K. (2007). Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy and technology. *Computers & Education*, 49(3), 740-762.
- Lee, K., Chai, C.S., & Koh, J.H.L. (2012). Fostering Pre-service Teachers' TPACK Towards Student-centered Pedagogy. In P. Resta (Ed.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2012* (pp. 3915-3921). Chesapeake, VA: AACE.
- Lee, M. H., & Tsai, C. C. (2010). Exploring teachers' perceived self efficacy and technological pedagogical content knowledge with respect to educational use of the World Wide Web. *Instructional Science*, 38, 1-21.

- Mishra, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. *Teachers College Record*, 108(6), 1017-1054.
- Nadelson, L. S., Callahan, J., Pyke, P., Hay, A., Dance, M., & Pfiester, J. (2013). Teacher STEM perception and preparation: Inquiry-based STEM professional development for elementary teachers. *The Journal of Educational Research*, 106(2), 157-168.
- Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2009). Technological Pedagogical Content Knowledge (TPACK): The development and validation of an assessment instrument for preservice teachers. *Journal of Research on Technology in Education*, 42(2), 123-149.

The Relationships between Child-Parent Shared Mobile Augmented Reality Picture Book Reading Behaviors and Children's cognitive attainment

Kun-Hung CHENG^{a*} & Chin-Chung TSAI^b

^aDigital Content Production Center, National Chiao Tung University, Taiwan

^bGraduate Institute of Digital Learning and Education, National Taiwan University of Science and Technology, Taiwan

*kuhu@mail.nctu.edu.tw

Abstract: Augmented reality (AR) books combining the advantages of physical books with digital content including new interaction possibilities are the one of the noticeable AR media. The application of AR book has been documented its effectiveness for learning, however, studies regarding how users learn in the process of AR book reading is limited. This study selected a mobile AR picture book to examine the relationships between child-parent shared reading behaviors and children's cognitive attainment. The reading behaviors of 33 child-parent pairs participated in this study were video-recorded and the children were interviewed after the activity for understanding their cognitive attainment. Through the correlation analysis, the findings indicated that the more reading and operation (i.e., turning or inspecting the AR book) of the mobile AR picture book the children were involved in, the more cognitive attainment they gained. The parental interaction-oriented behaviors (i.e., commenting, prompting, evaluating, or expanding) were helpful for their children's learning. Another noteworthy issue is that the distraction of the children during the shared reading process was negatively related to their cognitive attainment.

Keywords: augmented reality, picture book, child-parent shared reading, behavioral analysis, cognitive attainment

1. Introduction

The considerable attention of augmented reality (AR) with its technical capability of blending real-time virtual information over users' view of physical world is increasingly paid in education (Wu et al., 2013). AR allows users to transfer seamlessly between the real and virtual world and may create a new learning experience for conveying situational information beyond traditional learning context (Bujak et al., 2013). With the aid of AR, research has indicated its positive supports in science learning such as spatial ability, practical skills, conceptual understanding, and inquiry-based scientific activities (Cheng & Tsai, 2013). Learners could acquire better understanding in terms of physics in an AR system (Enyedy et al., 2012; Lin et al., 2013). It can be hence expected that the pedagogical application of AR probably becomes new learning paradigm (Duh, Klopfer, 2013).

AR books originated from the *MagicBook* (Billinghurst et al., 2001) combine the advantages of physical books with digital content including new interaction possibilities (Dünser, 2008). Researchers indicated that the AR technology may enhance learners' comprehension of book content through the interaction with synthetic information upon the book (Vate-U-Lan, 2012). Although the application of AR book has been documented its effectiveness for learning, studies regarding how users learn in the process of AR book reading is limited. Accordingly, this study selected a mobile AR picture book with artistic introduction, namely "*The adventures of Yuyu: Yuyu Yang artistic journey (published by National Chiao Tung University Press in Taiwan)*," for children and their parents to read together. The exploration of the relationships between child-parent reading behaviors and cognitive attainment of children is the attempts of this study.

2. Method

There were 33 pairs of children and their parents voluntarily participated in this study. The children were aged from 5 to 10 years old (mean=7.85, SD=1.58). They were all in primary school level except 5 children of preschoolers. The parents who ranged in age from 30 to 64 years old (mean=37.91, SD=5.51) generally had had the experience of using smartphones or tablet PCs.

This study invited the children and their parents to freely share the mobile AR picture book reading with an iPad in a pair setting. In the beginning of the activity, the reading process and the usage of the book were briefly instructed by a researcher. The entire reading process was videotaped for exploring the operation behaviors between children and their parents. When the activity finished, each child was interviewed for understanding their cognitive attainment regarding the content of the book. This study conducted quantitative content analysis to examine the video data (coding the behaviors in 5 second time slots) and the interview data of the children. A total of 7,468 coded behaviors of the children and parents were yielded; and 160 codes are classified as low level cognitive attainment and 47 codes are classified as high level cognitive attainment. Through the correlation analysis with the results of the frequency generated from the content analysis, the relationships between child-parent reading behaviors and cognitive attainment of children could be understood.

3. Results

After conducting the Pearson correlation analysis, Table 1 shows that the low level cognitive attainment (simply describing the appearance of the artistic work) of the children was related to the parents' behaviors of commenting ($r=0.54, p<0.01$) and raising prompts or questions ($r=0.38, p<0.05$) on the details of the AR book and further evaluating their children's responses ($r=0.38, p<0.05$). Similarly, in addition to the relationships between and the commenting ($r=0.43, p<0.05$), prompting ($r=0.49, p<0.01$), and evaluating ($r=0.45, p<0.01$) behaviors of the parents and the high level cognitive attainment of the children, it is interesting to note that the children were inclined to explain or create the imagination to describe the content of the AR book or the AR artistic work (high level cognitive attainment) when their parents provided additional information about the AR book for expanding the children's responses ($r=0.54, p<0.01$).

Table 1: The correlations between parent reading behaviors and cognitive attainment

	Low level cognitive attainment	High level cognitive attainment
Parent narrates the book for the child	-0.20	-0.11
Parent points at the book	0.11	0.04
Parent comments on the book	0.54**	0.43*
Parent prompts on the book	0.38*	0.49**
Parent evaluates the child's responses	0.38*	0.45**
Parent expands the child's responses	0.32	0.54**
Parent controls the AR book	-0.22	-0.21
Parent turns the AR book	-0.10	0.13
Parent disciplines the child	-0.17	-0.15

** $p<0.01$, * $p<0.05$

As shown in Table 2, the children's behaviors of reading themselves ($r=0.52, p<0.01$), turning ($r=0.64, p<0.01$), and inspecting ($r=0.50, p<0.01$) the AR book were linked to their low level cognitive attainment. However, according to Table 1, the narration and operation behaviors of the parents were not associated with the children's learning outcomes. The findings may imply the importance of the reading and operation of the mobile AR picture book by the children themselves rather than their parents. Moreover, the children's cognitive attainment had relationships with their behaviors of commenting on the AR book ($r=0.47, p<0.01$ for low level; $r=0.35, p<0.05$ for high level) and responding to their parents' prompts ($r=0.50, p<0.01$ for low level; $r=0.49, p<0.01$ for high level). Compared with the results in Table 1, this study considers that the children may be benefited when their

parents showed more interaction-oriented behaviors and they could show more tendencies to respond to their parents accordingly. In addition, the behaviors of losing focus on the AR book by the children were negatively related to their cognitive attainment ($r=-0.53$, $p<0.01$ for low level; $r=-0.36$, $p<0.05$ for high level). As a result, the distraction of the children during the child-parent shared mobile AR book reading process should be a noteworthy issue.

Table 2: The correlations between children reading behaviors and cognitive attainment

	Low level cognitive attainment	High level cognitive attainment
Child read himself/herself	0.52**	0.20
Child points at the book	0.31	-0.08
Child comments on the book	0.47**	0.35*
Child questions about the book	0.16	-0.08
Child responds to parent's prompts	0.50**	0.49**
Child controls the AR book	0.21	0.10
Child turns the AR book	0.64**	0.43*
Child inspects the AR elements	0.50**	0.19
Child intervenes in parent's operation	-0.16	-0.12
Child is distracted	-0.53**	-0.36*

** $p<0.01$, * $p<0.05$

References

- Billinghurst, M., Kato, H., & Poupyrev, I. (2001). The MagicBook: A transitional AR interface. *Computers and Graphics*, 25(5), 745-753.
- Bujak, K. R., Radu, L., Catrambone, R., MacIntyre, B., Zheng, R., & Golubski, G. (2013). A psychological perspective on augmented reality in the mathematics classroom. *Computers & Education*, 68, 536-544.
- Cheng, K. H & Tsai, C. C. (2013). Affordances of augmented reality in science learning: Suggestions for future research. *Journal of Science Education and Technology*, 22(4), 449-462.
- Duh, H. B. L., & Klopfer, E. (2013). Augmented reality learning: New learning paradigm in co-space. *Computers & Education*, 68, 534-535.
- Dünser, A. (2008). Supporting low ability readers with interactive augmented reality. *Annual Review of CyberTherapy and Telemedicine: Changing the Face of Healthcare*, 41-48.
- Enyedy, N., Danish, J. A., Delacruz, G., & Kumar, M. (2012). Learning physics through play in an augmented reality environment. *International Journal of Computer-Supported Collaborative Learning*, 7(3), 347-378.
- Lin, T. J., Duh, H. B. L., Li, N., Wang, H. Y., & Tsai, C. C. (2013). An investigation of learners' collaborative knowledge construction performances and behavioral patterns in an augmented reality simulation system. *Computers & Education*, 68, 314-321.
- Vate-U-Lan, P. (2012). An augmented reality 3D pop-up book: the development of a multimedia project for English language teaching. *Proceedings 2012 IEEE International Conference on Multimedia and Expo*, 890-895.
- Wu, H. K., Lee, S. W. Y., Chang, H. Y., & Liang, J. C. (2013). Current status, opportunities and challenges of augmented reality in education. *Computers & Education*, 62, 41-49.

Strategies for Leveraging Learning Game Data for Middle School Mathematics Instruction

Michael A. EVANS^{a*} & Jordan PRUETT^b

^aDepartment of Learning Sciences & Technologies, Virginia Tech, USA

^bDepartment of Mathematics, Virginia Tech, USA

*mae@vt.edu

Abstract: Middle school mathematics education is subject to ongoing reform based on advances in instructional technologies, leading to recent calls for investment in *learning games*. The pertinent issues focus on the device-based data collection potential of these dynamic, innovative learning environments to improve classroom instruction. Through an extensive literature review, we identified three priority areas where data collected from learning games could assist teachers to make informed decisions: *providing students with personalized feedback*, *assessing student learning*, and *promoting deeper learning*. These requirements are used to highlight potential empirical and practical implications for leveraging collected gameplay data to improve instruction, demonstrating how the *CandyFactory* app could be harnessed to support classroom-based decision-making. Investigators have partnered with a school district in rural southwest Virginia, testing how students (n=306) from two middle schools in six mathematics classrooms benefited from *CandyFactory* and how it influenced mathematics engagement and achievement. Through a series of three participatory design workshops (occurring from June 2012-June 2013), partnering teachers (n=6) confirmed that having access to data from the three identified priority areas would allow for an integrated adoption of learning games into instruction, potentially leading to achievement gains. We conclude by proposing future research directions in developing targeted learning games to support evidence-supported decision-making, which in turn could benefit how middle school students engage with and achieve in mathematics.

Keywords: evidence-supported decision making, learning games, mathematics education, middle school, tablet computing, teaching analytics

1. Introduction

A trending issue in education is to leverage the potential data collection opportunities available to technology-enhanced learning environments (TELEs) to promote classroom-based evidence-supported decision-making. For our purposes, we focus on learning games for tablet computers where this agenda could be rigorously developed, implemented, and evaluated. We define *learning games* as those that focus on gaining knowledge inconspicuously to foster habits and understanding for the classroom and have “learning as the primary objective” (Young et al, 2012, p. 63).

As a result, investigators have developed a learning game for the iPad called *CandyFactory*, targeted toward middle school-aged children learning fractions. Players traverse five increasingly complex levels, completing factory orders by fractioning off candy bars into the requested amounts. The fraction concepts reinforced are: *partitioning of a whole*, *copying*, and *measuring*. Prior efforts have focused on the effects on learning (Evans, Norton, Chang, Deater-Deckard & Balci, 2013; Norton, Wilkins, Evans, Deater-Deckard, Balci & Chang, in press). Moving forward, where support of teacher decision-making is prioritized, it would be beneficial to articulate what data could and should be collected in learning games to enhance instruction. The *CandyFactory* app is available for download via iTunes.

In the following sections we highlight a *design-based implementation research approach* (Cator et al, 2012) that focuses on, first, the potential data-collection features of *CandyFactory*, then the systemic decision-making process as a co-design activity with teachers and investigators. The following report is a third phase of iterative refinement to integrate design principles, co-design with teachers

(n=6), and analyze results from a medium-scale intervention (n=306). Details of these results are reported elsewhere (Evans, Chang, Kim, Samur, Deater-Deckard, Norton & Balci, 2013). Our goal is to highlight how instructional technologies and organizational systems could work together to improve middle school mathematics instruction *and* learning. This proposal aligns well with the call for submissions that report changes to research design and implementation, and how efforts are conducted in dynamic, innovative learning environments.

Table 1: Summary of data categories prioritized in learning games to enhance instruction.

Category	Definition	Data Collected	Benefits
Personalized Feedback	“Personalization is instruction that is paced to learning needs, tailored to learning preferences, and tailored to specific interests” (Cator et al., 2012, p. 26).	• Attitudinal Data • How a concept is represented and its difficulty • Supplementary exercises • Student’s ability to make adjustments • Evaluation from multiple sources at multiple points • Positive, immediate feedback	• Personalization • Reassess student’s understanding • Content can be customized
Student Assessment	“Assessment should be used to gather evidence that informs instructional decisions, and encourages learners to try to learn” (Woolf et al., 2010, p. 21).	• General Trait Variables (abilities and capabilities) • General State Variables (prior knowledge, etc.) • Situation-Specific Variables (engagement, etc.) • Student improvement • Success in implementing rules • Quickness/change of response time	• Reveal what and how players learned • Students’ understanding of rules applied • Evidence of 21st century competencies
Deeper Learning	“Deeper learning is defined as the ability to acquire, apply, and expand academic content knowledge and also to think critically and solve complex problems, communicate effectively, work collaboratively, and learn how to learn” (Hewlett Foundation, 2012; Cator et al, 2012, p. 11)	• Students’ attempts/# of attempts • # of hints and feedback given • Time allocated across each part of the problem • Whether or not student is “making sense of problems” • Whether or not student is “constructing explanations”	• Ability to transfer knowledge • Students thinking about concepts on their own • Thinking shifts from practice to problem solving

2. Priority Areas for Data Collection in Mathematical Learning Games

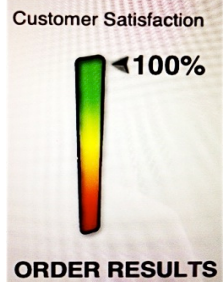
Recent reports suggest that data types to be collected in learning games should fall primarily under three categories: *personalized feedback*, *student assessment*, and *deeper learning* (Cator et al., 2012; Hewlett Foundation, 2012; Woolf et al., 2010). In the sections below, we combine findings from literature review with feedback gathered from participatory design workshops with teachers. We also highlight how *CandyFactory* could be leveraged to enhance evidence-supported decision-making innovations. These sections are summarized in Table 1.

Personalized Feedback

The first priority area for data collected is providing *personalized feedback*. Cator et al. (2012) describe personalization as instruction that is paced to learning needs, tailored to learning preferences, and adapted to specific interests (p. 26). A learning game requires the function of responsive algorithms to cater to a student's interactions with a pre-determined learning goal (Shute & Ke, 2012, p.46). Two types of feedback that promote game responsiveness are *performance feedback*, whether a behavior is right or wrong, and *informative feedback* that provides information on how to correct that behavior (p. 50). Performance feedback better fits learning games as it allows for rapid, immediate interaction, keeping students alert and thinking about gameplay, associating the feedback to the action, while teachers use it to determine what learners understand (Okita & Jamlian, 2011, p. 50, 52; Cator et al, 2012, p. 11).

Table 2: Data *CandyFactory* could capture to enhance *personalized feedback*.

Certain data should be collected to enhance personalized feedback: attitudinal data to determine a students' initial response to the game (Plass et al, 2013, p. 699); the type and number of feedback

Data Set	Picture	Why collect it?
Boss smiling or frowning when student completes order		- Feedback on whether the student completed the order correctly or not - Allows the student to see their level of performance as the game-play commences - Teachers can easily see the amount of problems the student gets correct versus incorrect by level or total game play
Number of times boss told student to work faster		- This reveals to the student whether or not they are working at a constant pace throughout the level - Teachers can easily identify a student's confusion at specific points in a level
Percentage given at end of level		- This percent along with the rating they are given, like "excellent", provides the student with an easy way to gage their overall performance - The teacher can see the passing percentage of the student and whether or not there has been improvement from the last time they played [The Math App].
Number of correct and incorrect responses & time it took for response		- The time the student spent on each response indicates whether time spent on a problem affects the outcome of the student's answer - Did the student take their time in completing the problem in order to earn the correct answer or were they just trying to complete the orders as fast as possible?

provided (including hints, examples, visual representations, etc.); the concept's difficulty (Cator et al, 2012, p. iii), allowing teachers to compare student performance on varied questions; and how quickly the feedback was given (immediate or delayed). This data should show if students make adjustments, thinking conceptually and practically about the concepts, while playing the game (Woolf et al, 2010, p. 32).

Data for personalized feedback that the teachers suggested include: real time data of students playing, a record of individual student data, a child's right vs. wrong list of fractions, and percent of accuracy. Taking into account the teacher's wishes and what the literature says, there is specific data that *CandyFactory* can collect in order to provide the students with the best, personalized feedback (see Table 2).

Student Assessment

The second priority area for data collected is *assessment of student learning*. "Assessment begins by figuring out what [teachers] want to assess and clarifying the intended goals, processes, and outcomes of learning" (Shute & Ke, 2012, p. 52). According to Okita & Jamalian (2011) student performance can be assessed in two ways: a student's performance while using the learning game, allowing student potential to be evaluated, and when a student's cognitive ability is challenged (p. 52), revealing what, how, and why they have learned (Plass et al, 2013, p. 700). Learning games do this by recording and monitoring student activity without interrupting gameplay or the student's thinking (Shute & Ke, 2012, p. 51), revealing whether students understand the rules they are applying without assistance (Okita & Jamalian, 2011, p. 52; Plass et al, 2013, p. 722). Assessments should infer whether students acquire competencies (collaboration, innovation, intellectual curiosity, self-regulation, self-direction, etc.) that the 21st century demands from playing learning games (Cator et al, 2012, p. 11). Shute & Ke say that a teacher should assess "student knowledge, skills, and understanding along with beliefs, feelings and other learner status and traits" (p. 53).

Data that should be collected for assessment include: general trait variables showing a learner's initial abilities; general state variables that include prior knowledge, students' awareness, and motivation; situational-specific variables showing cognitive load, the student's situational interest, and level of engagement (Plass et al, 2013, p. 699-700); and a student's improvement seen in implementation of rules, speed of work, change in response time, use of operations, and the amount of scaffolding (Cator et al, 2012, p. 52; Plass et al, 2013, p. 712). Okita & Jamalian (2011) suggest, "assessment becomes [an] important contributor to designing personalized learning environments" (p. 52); assessment helps benefit student learning by providing a personalized education.

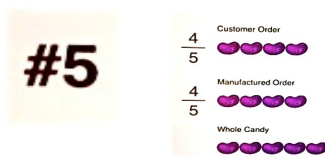
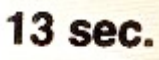
Student assessment data that our partner teachers would like to see captured includes student performance for every task including level, customer order, produced candy, times, and times pushed the back button; the rate of success on various levels; time spent on a single fraction; the time spent on a level; and points in the game where students get stuck and/or give up. *CandyFactory* could collect data to facilitate student assessment based on overlapping priorities expressed via the literature and participant teachers (See Table 3).

Deeper Learning

The third priority area for data collected is *promoting deeper learning*. Expectations in education have dramatically changed in recent decades, students should learn more, faster and teachers should discover new, exciting ways to teach, emphasizing the importance of deep learning. There are two approaches to learning: surface learning, where a student tries to "memorize given information by details" or deep learning "involv[ing] critical analysis of new ideas, linking them to known concepts, leading to long-term retention of concepts to be used for problem solving in unfamiliar contexts," and learning how to learn (Vos et al, 2011, p. 128; Cator et al, 2012, p.11). Deep learning approaches allow students to perform better in the classroom because they retain, integrate, and transfer information at a higher, quicker rate (Vos et al, 2011, p. 128). Learning games are a prime opportunity for deep learning because "play is voluntary, intrinsically motivating, and involves active, cognitive, and/or physical engagement allow[ing] for the freedom to fail (and recover), to experiment, and to fashion ideas" appealing to "decision making, knowledge transfer, and analytic, critical thinking, and problem solving

skills” (Shute & Ke, 2012, p. 44; Vos et al, 2011, p. 50; Okita & Jamalian, 2011, p. 128). Games also facilitate the “trial-and-error” approach supporting development of logical thinking and problem solving (Vos et al, 2011, p. 128). Learning games provide the opportunity for knowledge to be applied (Cator et al, 2012, p. 60; Devlin, 2011, p. 53), shifting from straightforward practice problems to solving real-life questions (Plass et al, 2013, p. 722).

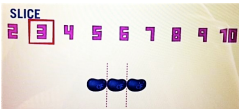
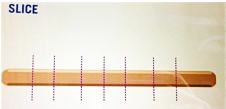
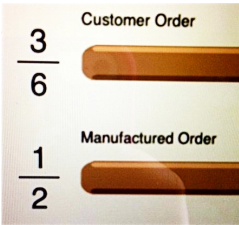
Table 3: Data *CandyFactory* could capture to enhance student assessment.

Data Set	Picture	Why collect it?
Number of correct, incorrect responses vs. number of responses completed		This shows the basic principle of did the student get more questions correct than they got incorrect.
Time spent on each response/level/game		- Identifier of understanding - Total time spent playing the app could show whether or not they are enjoying learning through the game play and are interested in continuing to play.
Time spent on/number of times visited instructions page		- Can show a lack of understanding of fraction rules, so the student is fishing in the directions for some kind of hint on how to complete the fractions correctly - Can show poor game design, so the student is trying to figure out how to navigate the gaming processes correctly
Time spent on/number of times visited trophy page		- Good indicator of a student's motivation - Visit the trophy page consistently- motivation may stem from a desire to gain all the trophies available in order to “beat the game.” - Rarely visit trophy page- motivation must come from somewhere else

Data that should be collected to show evidence of deep learning include: student inputs, number of attempts, and number of hints indicating what a student has learned; the amount of time a student takes to complete parts of a problem, showing strengths and weakness of concepts; and a student's

rationale to the answer chosen, revealing their thought process and whether they are “making sense of problems” (Cator et al, 2012, p. 10). “In summary, games seem to comprise all elements for a learning environment in which students are stimulated to use deep learning strategies” (Vos et al, 2011, p. 130).

Table 4: Data *CandyFactory* could capture to enhance *deeper learning*.

Data Set	Picture	Why collect it?
Number of times student went back a screen		- Understanding of fractions compared to guess-and-check - If the student truly has a deep knowledge in fractions, back button won't be used as often
Time spent on each screen		- Time spent on: partitioning, copying, or measuring- struggle with a specific concept of fractions may become evident - Are they understanding that a fraction is a part of a whole or that $\frac{2}{3}$ is bigger than $\frac{1}{3}$?
Level 1: Number of different slice numbers chosen		Shows whether or not the student could visualize partitioning the candy into the correct fraction.
Level 2: Number of times player “measured out” swipes/where were swipes placed		- Understanding of partitioning - Are they using the swipes as a visual guide or as guess-and-check and are they placing the swipes in a logical manner? - Do they understand the amount of swipes it takes to partition the fraction correctly?
Level 3: Equivalent fractions AND success on smaller vs. larger fractions		- Success on smaller ($\frac{1}{2}$) or larger ($\frac{3}{6}$) fractions - Use of equivalent fractions - Correctly visualize pieces of a whole - Use of most simplified form of fraction (using $\frac{1}{2}$ instead of $\frac{3}{6}$)
Level 4: speed of completing and number of correct/incorrect partial vs. improper fractions		- Success on partial fractions vs. improper fractions - Understanding of improper fraction format ($\frac{15}{8}$) compared to a mixed number format ($2\frac{1}{8}$) - Able to visualize that an improper fraction is still part of a whole added to another whole?

Level 5: time to complete all 6 fractions		Shows whether or not they know the difference in the numerator and the denominator and that rearranging them is not equivalent (Student must fix $\frac{3}{6}$ to $\frac{6}{6}$).

Participant teachers desired evidence that students were gaining deeper knowledge of fractions by playing *CandyFactory*, beyond conventional differences between pre-/post-test results. Teachers prefer progress data for individual students, showing improvement in student knowledge to track progress and growth over time; length of time a student spent on each fraction; amount of on-task working versus off-task working; and the speed of completing problems. There are also more specific data by level that *CandyFactory* could capture to show deeper learning (See Table 4). Having the teachers' perspectives after implementing *CandyFactory* in their classrooms has provided preliminary evidence of how the three data categories – personalized feedback, student assessment, and deeper learning – could be potentially used to facilitate learning of core mathematics concepts.

3. Enhancing Decision-Making in the Middle School Mathematics Classroom

Our position is that the data collection capabilities of learning games alone are an insufficient technological solution that does not fully account for the institutional requirements for innovation in technology-enhanced learning environments. Subsequently, Anfara (2010) suggests four phases to prepare teachers in their professional capacities to adopt evidence-supported decision-making processes: *organization for success*, *building assessment literacy*, *identifying the data that should be used*, and *altering instruction* (p. 56). In the following sections we highlight how [The Team] is using this framework to co-design a potentially successful implementation of learning games in the middle school classroom. Our review of the literature has indicated that calls for data-driven instructional innovations have neglected matters of organizational learning and change.

Time is a barrier for teachers. Thus, organizing for success allows for efficient decision-making (Anfara, 2010, p. 57). A solution to lack of time is to create meetings, or data-routines (Anfara, 2010, p. 57; Goren, 2012, p. 234) that foster an environment for data discussion, learning from others' experiences, and altering teaching techniques to help with implementation in the classroom (Spillane, 2012, p. 113). Investigators have begun to provide the teachers with an example of data routines in the PD sessions, allowing for discussion on data potential for *CandyFactory*. Combining the second and third phase, assessment literacy and identifying data to be used, *CandyFactory* has provided the three data categories to alleviate the burden of analyzing every data point a learning game could collect, focusing teachers on the identified data that is important to learning. The final phase, altering instruction (Anfara, 2010, p. 56), is the primary goal for *CandyFactory*. The teachers expressed that the ultimate goal for *CandyFactory* should be embedding the game into curriculum, having lesson plans and assessment and reflective questions to go along with the game. Investigators intend to implement this idea into the project to help teachers better use the app to enhance instruction. The three data categories and the steps investigators have taken to help fulfill Anfara's (2010) four phases of decision-making will allow teachers to make decisions in the classroom more efficiently.

"Data do not objectively guide decisions on their own—people do"— "the interpretations teachers make from data, especially the implications they will draw for instructional change, are influenced by teacher knowledge" (Spillane, 2012, p. 114; Goren, 2012, p. 234). Data-use is not effective without teacher background knowledge, in our case in mathematics and education. Coupling teacher experience with the techniques provided in this manuscript, evidence-supported decision-making can be easily implemented in middle school mathematics classrooms to help better students' learning.

Acknowledgements

This material is based on work supported by the National Science Foundation (NSF) under Grant No. DRL-1118571, and the Scieneering Undergraduate Research Program, the Institute for Creativity, Arts, and Technology (ICAT), and the Institute for Society, Culture, and Environment (ISCE) at Virginia Tech. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of sponsoring organizations. The Learning Transformation Research Group at Virginia Tech includes the authors and a talented team of co-investigators (Kirby Deater-Deckard, Anderson Norton, Osman Balci), and graduate and undergraduate research assistants.

References

- Anfara Jr., V.A. (2010). Data-Driven Decision Making. *Middle School Journal* 42(2), 56-63.
- Ball, C.R., & Christ, T.J. (2012). Supporting Valid Decision Making: Uses And Misuses Of Assessment Data Within The Context Of RTI. *Psychology In The Schools* 49(3), 231-244.
- Cator, K., & Adams, B. (2012). *Expanding Evidence Approaches for Learning in a Digital World*. Working paper. U.S. Department of Education Office of Educational Technology.
- Devlin, K.J. (2011). *Mathematics Education for a New Era: Video Games as a Medium for Learning*. Natick, MA: K Peters.
- Evans, M.A., Chang, M., Kim, S.*, Samur, Y., Deater-Deckard, K., Norton, A., & Balci, O. (2013). *Learning games and student mathematics proficiency: Investigating differential effects on grade level and ability*. Unpublished manuscript.
- Evans, M. A., Norton, A., Chang, M., Deater-Deckard, K., & Balci, O. (2013). Youth and Video Games. *Zeitschrift für Psychologie*, 221(2), 98-106.
- Goren, P. (2012). Data, Data, And More Data-What's An Educator To Do? *American Journal Of Education*, 118(2), 233-237.
- Linda Heitzman-Powell, et al. (2012). Using Technology To Support Progress Monitoring And Data-Based Intervention Decision Making In Early Childhood: Is There An App For That?." *Focus On Exceptional Children* 44(8), 1-18.
- Norton, A., Wilkins, J. L. M., Evans, M. A., Deater-Deckard, K., Balci, O., & Chang, M. (in press). Transcending part-whole conceptions of fractions. *Mathematics Teaching in the Middle School*.
- Okita, S.Y., & Jamalain, A. (2011). "Current Challenges in Integrating Educational Technology into Elementary and Middle School Mathematics Education." *Journal of Mathematics Education at Teachers College* 2(2).
- Plass, J.L., Homer, B.D., Kinzer, C.K., Chang, Y.K., Frye, J., Kaczetow, W., Isbister, K., & Perlin, K. (2012). Metrics in Simulations and Games for Learning. 697-729.
- Shute, V.J., & Ke, F. (2012). Games, learning, and assessment. *Assessment in Game-Based Learning*. Springer New York, 43-58.
- Spillane, J.P. (2012). Data In Practice: Conceptualizing The Data-Based Decision-Making Phenomena. *American Journal Of Education* 118(2), 113-141.
- Vos, N., van der Meijden, H. & Denessen, E. (2011). Effects of constructing versus playing an educational game on student motivation and deep learning strategy use. *Computers & Education* 56(1), 127-137.
- Woolf, B.P. (2010). *A Roadmap for Education Technology*. Publication. Comp. Global Resources for Online Education. National Science Foundation.
- Young, M.F., et al. (2012). Our Princess Is in Another Castle A Review of Trends in Serious Gaming for Education." *Review of Educational Research*, 82(1), 61-89.

Examining the effects of integrating technological pedagogical content knowledge into preschool teachers' professional development regarding science teaching: using digital game-based learning as an example

Chung-Yuan HSU^{a*}, Yi-Ching SU^b, & Jyh-Chong LIANG^c

^aDepartment of Child Care, National Pingtung University of Science and Technology, Taiwan

^bDepartment of Child Care and Family Studies, Asia-Pacific Institute of Creativity, Taiwan

^cGraduate Institute of Applied Science and Technology, National Taiwan University of Science and Technology, Taiwan

*jackohio@mail.npust.edu.tw

Abstract: A common question emerges while applying the Technological Pedagogical Content Knowledge framework for teachers' preparation to integrate ICT into classroom teaching and learning: which type of knowledge (e.g., TK, CK, or PK) should be instructed first during the course? This study examined the effects of the technology- and pedagogy-oriented course design on improving the in-service preschool teachers' Technological Pedagogical Content Knowledge-Games (TPACK-G) as well as their acceptance of digital game-based learning. The participants were 49 in-service preschool teachers. They were assigned into a technology- and a pedagogy-oriented group. The results show that when integrating the TPACK-G framework into the preschool context, instructing game knowledge before pedagogy knowledge tended to raise the in-service teachers' competencies of game knowledge and game-pedagogical-content knowledge.

Keywords: TPACK, games, preschool, game-based learning

1. Introduction

With the greater accessibility of information technology in education, there is a growing emphasis on utilizing digital games (hereafter named games) to support teaching and learning. Games have the potential of engaging students in active and meaningful learning (Dickey, in press). However, harnessing this potential requires a framework to help teachers integrate games into their teaching. Hsu and Chai (2012) proposed a framework of Technological Pedagogical Content Knowledge-Games (TPACK-G). Developed from the ideas of TPACK (Mishra & Koehler, 2006), the TPACK-G framework consists of game knowledge (GK), game pedagogical knowledge (GPK), and game pedagogical content knowledge (GPCK). GK is defined as the knowledge about the general usage of computer games. GPK refers to the knowledge of using games with various pedagogical characteristics for teaching without specific reference to content knowledge. Last, GPCK is knowledge of using games to implement teaching methods for any targeted content. Much TPACK research has investigated the inter-relations among the various types of TPACK knowledge by using path analysis (Chai, Koh, Tsai, & Tan, 2011; Hsu & Chai, 2012). For instance, in Chai et al.'s (2011) study on exploring pre-service teachers' TPACK development after completing the ICT curriculum, the results showed that the participants' TK, CK and TPK could predict their TPACK. Meanwhile, Hsu and Chai (2012) also found that the participants' GK was able to predict their GPK, and then their GPK could further predict their GPCK. Although the relations among the different types of TPACK knowledge can be identified by using path analysis, which type of knowledge (i.e., TK, CK, or PK) should be instructed first during the

course in order to improve students' TPACK is still unknown. Thus, the purpose of this study was to investigate the impacts of course design on the preschool teachers' confidence in their TPACK-G and their acceptance of game-based learning. Specifically, this study was guided by the following questions:

1. What were the effects of the technology- and pedagogy-oriented course design on improving the in-service preschool teachers' TPACK-G?
2. Is there any significant difference in the participants' acceptance of digital game-based learning?

2. Methodology

Participants

The participants were 49 college students recruited from two intact classes in northern Taiwan. They were all in-service preschool teachers who were taking advantage of the weekends to get a college degree in child care and education. Being a preschool teacher in Taiwan does not require a bachelor's degree. Anyone who graduates from a junior college or a vocational school and has a major in a related field is eligible to become a preschool teacher. Thus, the participants of this study had diverse academic backgrounds. Except for one missing value, 35 had a vocational school diploma, 12 had a college degree in a non-child care major, and one had a master's degree. They were all female, the average age was 37.5 (SD = 7.42) and the average teaching experience was 11.21 years (SD = 5.19).

Instruments

This study employed two questionnaires, the Technological Pedagogical Content Knowledge-Games (TPACK-G) and the Acceptance of Digital Game-Based Learning (ADGBL) survey, to assess the preschool teachers' confidence in TPACK-G and their acceptance of digital game-based learning. The TPACK-G instrument was developed by Hsu and Chai (2012) according to the previous work of Chai, Koh, and Tsai (in press) and Lee and Tsai (2010). Consisting of 14 items, the survey measures the participants' confidence in game knowledge, game pedagogical knowledge, and game pedagogical content knowledge. Descriptions of the three scales are presented below. In the study of Hsu and Chai (2012), the original reliability (Cronbach's alpha) coefficients for these factors ranged from 0.90 to 0.94 and the overall alpha was 0.95. In this study, the reliability coefficients were 0.92, 0.93, 0.93, and 0.94, respectively for GK, GPK, GPCK, and the overall alpha. This suggests satisfactory reliability of assessing the participants' confidence in TPACK-G.

1. *Game Knowledge (GK)*: the teacher knows how to use digital games; for instance, 'I can learn how to use digital games easily.'
2. *Game-Pedagogical Knowledge (GPK)*: the teacher knows how to use digital games to enhance students' learning, such as 'I am able to facilitate my students to use digital games to observe some phenomena.'
3. *Game-Pedagogical-Content Knowledge (GPCK)*: the teacher knows how to use appropriate pedagogy and digital games to support students' learning of specific content through, for example, teaching lessons that appropriately combine the teaching subject, digital games and teaching approaches.

The ADGBL survey contains factors of learning opportunities, preference for games, experience with games, and attitudes toward game-based learning. Descriptions of these factors with sample items are presented below. Similarly, this instrument was proposed in Hsu and Chai's (2012) study underlying the research of Bourgonjon, Valcke, Soetaert, and Schellens (2010) as well as that of Lee and Tsai (2010). There were 20 items in total. The original reliability coefficients reported in Hsu and Chai's (2012) study ranged from 0.91 to 0.95 with an overall alpha of 0.96. In this study, the reliability coefficients were 0.91, 0.80, 0.92, 0.95, and 0.92, respectively for LO, PFG, EWG, ATT, and the overall alpha. All of the items of the two instruments described above were presented with a 7 point Likert scale, namely: 1) Strongly disagree; 2) Disagree; 3) Slightly disagree; 4) Neither agree nor disagree; 5) Slightly agree; 6) Agree; 7) Strongly agree.

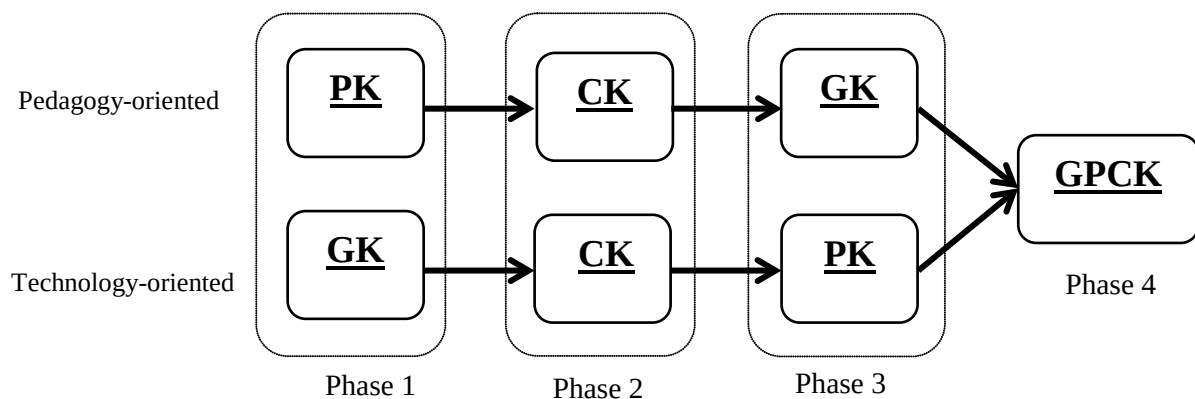
1. *Learning opportunities (LO)*: the teacher believes in affording learning opportunities when using

- games in the classroom; for instance, ‘Games offer opportunities to experiment with knowledge.’
2. *Preference for games (PFG)*: the teacher prefers the usage of games in the classroom; for example, ‘If I had to vote, I would vote in favor of using digital games in the classroom.’
 3. *Experience with games (EWG)*: the teacher likes playing games; for example, ‘Compared to people of my age, I play a lot of digital games.’
 4. *Attitudes toward Game-based learning (ATT)*: the teacher agrees with using digital games in teaching; for instance, ‘Digital game resources can enrich course content.’

Research treatments

The participants of the two classes were enrolled in a course on Children’s Health Care that was developed according to the framework of TPACK-G. Its course objective was to enable the students to design games and integrate them into the course activities. In order to examine how different orientations of the course design influenced the students’ TPACK-G as well as their acceptance of digital game-based learning, the curriculum was designed as either pedagogy- or technology-oriented. These two courses consisted of four phases (see Figure 1). As shown, the pedagogy-oriented course started with teaching pedagogy knowledge (PK) in Phase 1, followed by content knowledge (CK), and technology knowledge (GK). An inter-relationship of pedagogy, content, and technology knowledge (GPCK) was instructed in the end. The technology-oriented course, however, began with teaching GK first, followed by CK, PK, and TPACK. The course activities of each phase were inter-related. Take teaching the GK phase for instance; the course initially focused on game-related knowledge such as introducing digital games, game development, related software, gameplaying methods, and evaluation. Following GK was a description of its inter-relation with CK and PK. That is, the activities introduced how to use games to represent the subject content and how to facilitate students to use games to enhance their own learning.

The content of the pedagogy- and technology-oriented courses was exactly the same; only the teaching sequences differed. The time spent on each phase was six hours. During each treatment, the time was evenly divided for the teachers’ instruction and the students’ group discussion or practice, which allowed more time to construct their understanding. This study used a quasi-experimental design by assigning a class of 24 students to be the technology-oriented group and the other class of 25 students to be the pedagogy-oriented group. They all received instruction from the same instructors.



Data analysis

The descriptive statistics report on the demographic data, such as age, teaching experience, and the participants’ TPACK-G and acceptance of digital game-based learning before and after the treatment. Analyses of covariance (ANCOVA) were conducted with group as the independent variable to examine whether any significant difference existed in the two groups of the participants’ TPACK-G and acceptance of digital game-based learning.

3. Results

What were the effects of the technology- and pedagogy-oriented course design on improving the in-service preschool teachers' TPACK-G?

Table 1 shows the mean and standard deviation (SD) of the participants' TPACK-G scores before and after the treatment. An ANCOVA was conducted by using the TPACK-G scores before the treatment as the covariate and using the TPACK-G scores after the treatment as the dependent variables. The results revealed that statistically significant differences were identified in GK ($F = 9.46$, $p < .01$, $\eta^2 = 0.17$) and GPK ($F = 11.20$, $p < .01$, $\eta^2 = 0.20$), suggesting a large effect size based on Cohen's criteria (1988). Students in the TK group outperformed those in the PK group in terms of their GK and GPK. This finding implies that the participants who took the technology-oriented course first tended to have better performance on their GK and GPK.

Table 1. Summary of the descriptive statistics of students' pre- and posttest scores on the TPACK-G and ANCOVA.

Factor	Group	Before treatment		After treatment		Univariate ANCOVA			
		Mean	SD	Mean	SD	Mean (adjusted)	Standard error	F	η^2
GK	TK	4.66	1.20	4.81	.83	4.81	.19	9.46*	.17
	PK	4.64	1.22	3.98	1.03	3.98	.19		
GPK	TK	4.94	1.13	5.43	.97	5.35	.20	3.60	.08
	PK	4.70	1.23	4.83	.97	4.80	.20		
GPKC	TK	4.42	1.14	5.47	1.06	5.48	.21	11.20*	.20
	PK	4.10	1.34	4.50	.98	4.49	.21		

* $p < .01$

Is there any significant difference in the participants' acceptance of digital game-based learning?

Similarly, an ANCOVA was conducted by using the ADGBL scores before the treatment as the covariate, and using the ADGBL scores after the treatment as the dependent variables. The results merely identified a statistically significant difference, EWG ($F = 5.13$, $p < .05$, $\eta^2 = 0.10$), suggesting a medium effect size based on Cohen's criteria (1988). Students who took the technology-oriented course first were inclined to describe themselves as being more experienced with games.

Table 2. Summary of the descriptive statistics of students' pre- and posttest scores on the ADGBL and ANCOVA.

		Before treatment		After treatment		Univariate ANCOVA			
		Mean	SD	Mean	SD	Mean (adjusted)	Standard error	F	η^2
LO	TK	5.64	.93	5.77	.96	5.77	.20	.57	.01
	PK	5.52	.78	5.57	.91	5.52	.20		
PFG	TK	4.67	1.35	4.99	1.29	4.96	.27	.14	.00
	PK	4.26	1.22	4.68	1.44	4.82	.27		
EWG	TK	4.12	1.36	4.33	1.31	4.31	.27	5.13*	.10
	PK	3.46	1.36	3.41	1.27	3.43	.27		
ATT	TK	5.43	1.11	5.58	1.05	5.58	.20	.32	.01
	PK	5.39	.94	5.74	.88	5.74	.20		

4. Discussion and conclusion

The present study investigated the effects of a technology- and pedagogy-oriented course on the in-service preschool teachers' TPACK-G and acceptance of digital game-based learning. The results show that the technology-oriented group outperformed those in the pedagogy-oriented group in terms of their GK and GPCK. This finding suggests that when integrating the TPACK-G framework into the preschool context, instructing game knowledge before pedagogy knowledge tended to raise the in-service teachers' competencies in GK and GPCK. It was likely that teaching game knowledge first allowed the participants to get an idea of what games were and how games worked, which helped them articulate their tacit knowledge in the following phases of instruction (e.g., CK, PK, GPCK) and later enhanced their GPCK. Moreover, students who learned game knowledge first were inclined to perceive themselves as being more experienced with games. For future research, it is suggested that a qualitative approach be utilized to probe how students' TPACK-G develops over time. In addition, measurement of learning outcomes is also an important indicator to examine the impacts of the technology- and pedagogy-oriented groups.

References

- Bourgonjon, J., Valcke, M., Soetaert, R., & Schellens, T. (2010). Students' perceptions about the use of video games in the classroom. *Computers & Education*, 54(4), 1145-1156. doi: 10.1016/j.compedu.2009.10.022
- Chai, C. S., Koh, J. H. L., & Tsai, C.-C. (in-press). A review of Technological Pedagogical Content Knowledge. *Education Technology and Society*.
- Chai, C. S., Koh, J. H. L., Tsai, C.-C., & Tan, L. L. W. (2011). Modeling primary school pre-service teachers' Technological Pedagogical Content Knowledge (TPACK) for meaningful learning with information and communication technology (ICT). *Computers & Education*, 57, 1184-1193. Doi: 10.1016/j.compedu.2011.01.007
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum.
- Dickey, M. D. (in press). K-12 teachers encounter digital games: a qualitative investigation of teachers' perceptions of the potential of digital games for K-12 education. *Interactive Learning Environments*. doi: 10.1080/10494820.2013.788036
- Hsu, C.-Y. & Chai, C.-S. (2012, November). Exploring preschool teachers' technological pedagogical content knowledge with educational games. The 20th International Conference on Computers in Education (ICCE 2012), Singapore.
- Lee, M. H., & Tsai, C.-C. (2010). Exploring teachers' perceived self-efficacy and technological pedagogical content knowledge with respect to educational use of the World Wide Web. *Instructional Science*, 38, 1-21. doi: 10.1007/s11251-008-9075-4

Development of the Chinese Pre-service Teachers' Technological Pedagogical Content Knowledge Scale

Guoyuan SANG^a, Yan DONG^{a*}, Ching Sing CHAI^b & Ying ZHOU^a

^a Faculty of Education, Beijing Normal University, China

^b National Institute of Education, Singapore

*corresponing.author

Abstract: In this article the development and validation of the Chinese Pre-service Teachers' Technological Pedagogical Content Knowledge Scale (CTPCK) are described. The CTPCK is a 42-item scale for assessing pre-service teachers' knowledge with or without linking educational technology. The sample was split into two subsamples on random basis (n1 = 229, n2 = 207) for having, (1) Exploratory Factor Analysis (EFA) and (2) Confirmatory Factor Analysis (CFA), respectively. After the EFA, the CTPCK scale excluded 4 items and had 8 factors. Reliability and correlations were discussed. The findings revealed that the CTPCK scale was a valid and reliable instrument for measuring TPACK of Chinese pre-service teachers.

Keywords: TPACK; teacher education; exploratory factor analysis; confirmatory factor analysis

1. Introduction

Since recent decades, researchers (e.g., Godfrey, 2001; Becker, 2000) stress the potential of educational technology using in educational contexts to enrich learning environments, to foster flexible knowledge construction, to cater for individual differences (Godfrey, 2001), and to improve the quality of education. In order to reach those aims of using educational technology, school teachers should be prepared for successful integration of educational technology into their teaching practices.

Technological pedagogical content knowledge (TPACK) has been a burgeoning focus of research especially among teacher educators and researchers who are working in the field of educational technology (Chai, Koh, Tsai, 2013).

By understanding the relative influences of these different factors, teacher educators can better support ICT program design and evaluation. However, such kinds of studies have not often been carried out as many TPACK surveys are still in the process of construct validation (see Graham et al., 2009; Schmidt et al., 2009).

As Kabakci Yurdakul et al. (2012) pointed out, the approaches related to technology integration in education have transformed from technocentric integration to techno-pedagogical integration. However, researchers argue that student teachers in China are not being well prepared with TPACK since they are being offered courses mainly focusing on "hard technology" (e.g, Microsoft Office, Flash) knowledge separating from specific educational contexts (Zhan & Ren, 2011).

The key objective of this article is to have a better understanding of student teachers' perception about TPACK. This can be related to the improvement of quality of student teachers and the potential success of educational reforms in China.

2. Theoretical background

2.1 Defining TPACK

Already in 2001, the term technological pedagogical content knowledge (TPCK) was used to define technology integration in classroom (Keating & Evans, 2001; Pierson, 2001). As a framework of

describing the professional knowledge of teaching with technology, was again introduced by Koehler and Mishra (2005).

Originally, TPCK is derived from Shulman's (1986) well-known work on Pedagogical Content Knowledge (PCK), which has been considered a unique feature of teachers' professional level – teachers are able to integrate subject knowledge with appropriate pedagogical approaches so that learners are able to understand the subject (Voogt, Pareja Roblin, & Tondeur et al., 2013). TPCK adds technology related knowledge (TK) as an indispensable part of teachers' profession, in the age of information and technology.

TPACK refers to the synthesized form of knowledge for the purpose of integrating educational technology into classroom practices (Chai et al., 2013). Originally given the acronym of TPCK, the acronym has recently been changed to TPACK for the ease of pronunciation (see Thompson & Mishra, 2007). TPACK has been described as situated, complex, multifaceted, integrative and/or transformative knowledge (Angeli & Valanides, 2009; Koehler & Mishra, 2009).

The three main components (constructs) of teacher knowledge in the TPACK framework are Content Knowledge (CK), Pedagogical Knowledge (PK) and Technological Knowledge (TK). The other components, PCK (Pedagogical Content Knowledge), TCK (Technological Content Knowledge), TPK (Technological Pedagogical Knowledge), and TPACK (Technological Pedagogical Content Knowledge), consist of the interactions between and among these bodies of knowledge (Koehler & Mishra, 2005; Koehler & Mishra, 2009). Among all components, TPACK component is the basis of the framework since it is found in the interplay of all the components.

2.2 The measuring of TPACK

Only of questionnaire survey measurement of TPACK is being discussed in this section, considering the methodological base of this article.

2.2.1 Attempts of measuring TPACK

As Voogt et al. (2012) reviewed, the seven components of the TPACK framework were represented as sub-scales. Efforts to construct surveys for this purpose began with Koehler and Mishra (2005). They constructed a 14 items survey to chart 12 graduate students' developmental trajectories as these teachers were engaged in designing ICT integrated lesson. One other study on the measurement of TPACK was carried out by Archambault and Crippen (2009), focusing on examining teachers' knowledge with respect to each one of the components of the TPACK framework. Another study on developing a TPACK survey was carried out by Sahin (2011), including seven subscales based on the seven components of TPACK framework. Schmidt et al. (2009) constructed the Survey of pre-service Teachers' Knowledge of Teaching and Technology with 124 pre-service teachers in the USA which consisted of 58 items that measures all the seven constructs of TPACK. TPACK surveys have also been administered also with Asian teachers. Chai and his colleagues have carried out a series of surveys to investigate the profiles of Singaporean pre-service teachers in terms of their TPACK (e.g., Chai, Koh, & Tsai, 2010b; Chai, Koh, Tsai, & Tan, 2011). For instance, Chai et al. (2011) were able to uncover five of the seven TPACK constructs, which were a better model fit as compared with several extant studies of TPACK surveys.

Recently, researchers have discussed the potential of the Internet/Web technology for improving teaching practices (Barrbera, 2004; Lee & Tsai, 2010; Wallace, 2004). For instance, Lee and Tsai (2010) developed a 30-item TPACK survey focusing on the self-efficacy of Taiwanese teachers for web-based learning with respect to four TPACK constructs, namely web-general and web-communicative (i.e. two factors of TK), web-content knowledge (i.e. TCK), web-pedagogical knowledge (i.e. TPK), web-pedagogical content knowledge (i.e. TPACK) and an additional construct of attitudes towards web-based instruction.

2.2.2 Challenges of construct validation

Several studies reported difficulties and challenges with TPACK construct validation. Especially, the 7-component TPACK framework could not be reproduced through EFA (Archambault & Barnett, 2010; Koh et al., 2010), claiming that the boundaries between the components are fuzzy (Graham, 2011; also

see Voogt et al., 2012). For instance, Archambault and Barnett's (2010) exploratory factor analysis of a TPACK survey for online teaching found that the items for CK, PK and PCK loaded as one factor whereas the items for TPK, TCK, and TPCK loaded as another. Lee and Tsai (2010) were able to isolate the factors of TK, TPK, TCK and TPACK, but found that the PK and PCK items had loaded as a factor.

While Chai and his colleagues' effort to validate the TPACK instrument is laudable, the only validation that involves both EFA and CFA (Chai et al., 2011) uses the same participants. This may suffer in terms of research rigor instrument validation. Chai and colleagues subsequent studies reported solely CFA, including a recent study for pre-service teachers from China, Taiwan and Singapore (Chai et al., 2013). To ensure that the TPACK survey possess high quality of reliability and validity, this study builds-on Chai and his colleagues work to validate a Chinese version of TPACK survey for China pre-service teachers. The validation of this survey would then allow China teacher education institutes to surface their pre-service teachers' TPACK profile for the planning, implementation and assessment of the effectiveness of pre-service teacher preparation.

2.3 Purpose of the present study

Taken into account the challenges of construct validation of previous study and necessities of a Chinese version of TPACK to fit in with Chinese culture and educational settings, the purpose of the present study is to develop and validate a measure to empirically measure and describe pre-service teachers technological pedagogical content knowledge. To serve this purpose, the present article contains three distinct phases: (1) to develop an item pool on pre-service teachers technological pedagogical content knowledge and explore its factor structure; (2) to confirm and refine the received instrument; (3) to explore the correlations between different factors of the scale.

3. Methodology

3.1 Data source

The CTPCK items were originally from TPACK-ML survey in Singapore (Chai et al., 2011). In their study, the survey instruments developed by Schmidt et al (2009) and Koh et al. (2010) were selected as it could be adapted to analyze the CK of Singapore teachers with respect to the variation of their teaching subjects. Chai and his colleagues created 13 items to substitute the PK items in Schmidt et al.'s (2009) survey to better address the pedagogical emphasis of our ICT course. TKW (technological knowledge about the World Wide Web) was added to development of the instrument of the present study, considering the crucial importance of Internet for students and teachers. The original English version instrument used in Singaporean settings was translated into Chinese by one of the authors then rechecked by 3 scholars in educational sciences. All the four participants had excellent bilingual competence of both languages.

The final instrument therefore comprised 42 questions that were measured on a 7-point Likert scale where: (1) Strongly disagree (2) Disagree (3) Slightly Disagree (4) Neither Agree Nor Disagree (5) Slightly Agree (6) Agree (7) Strongly Agree.

3.2 Sample

The CTPCK was presented to 445 undergraduate pre-service teachers in a teacher education institute in Beijing (China). A total of 445 respondents, representing a response rate of 100%, completed the questionnaire. A total of 9 respondents had more than 10% missing data and were removed from the analysis. As a result, there were 436 pre-service teachers participating in this study. The sample included 293 (67.2%) female and 143 (32.8%) male respondents. The age of the respondents ranged from 17 to 25 years, with an average of 20.6 years. In regard to family location of the participants, 232 (53.2%) were from rural regions and 192 (44%) from urban regions. Studying years of students were asked. 179 (41.1%) of respondents were freshmen, 86 (19.7%) were sophomores, 113 (25.9%) were juniors, and the reminder 58 (13.3%) were seniors. As to majors the participants taking, 7 majors were reported: Chinese language (79, 18.1%), English language (66, 15.1%), history (73, 16.7%), educational technology (64, 14.7%), mathematics (59, 13.5%), physics (81, 18.6%), and psychology (14, 3.2%).

3.3 Analysis

To develop and evaluate the CTPCK, we conducted factor analyses. First, exploratory factor analyses (principal axis factoring) using SPSS were carried out on the results of a first stratified randomly selected subsample ($n = 229$) to identify clusters in the scales concerning the technological pedagogical content knowledge. Second, in order to examine the stability of the exploratory factor structure, after removing items with low factor loadings and cross loadings, confirmatory factor analyses (CFA) was performed on the data of the second stratified randomly selected subsample ($n = 207$), using AMOS 18, following the procedures recommended by Hair, Black, Babin, and Anderson (2010). Next, the results of the confirmatory factor analyses were reexamined on the data of the first subsample. Last, the reliability of the scores of the final version of the CTPCK was determined.

4. Results

4.1 Exploratory factor analyses

The results of a first stratified random subsample ($n = 229$) were used to carry out exploratory factor analyses, which helped identify a number of latent factors of pre-service teachers' technological pedagogical content knowledge. In order to reset the correlations between factors and to help interpret the factors, Varimax Oblimin rotation was used. The number of factors, the lower limit of the item eigenvalue was taken as 1.00 to determine the number of factors. Moreover, the factor load lower limit of each item was taken as .40 (DeVellis, 2003; Field, 2005; Netemeyer, Bearden, & Sharma, 2003), and the lower limit of the differences of each item within the factors was taken as .10 (Coombs & Schroeder, 1988; R. B. Kline, 2005; Tabachnick & Fidell, 1996). The KMO sample competency was measured in order to test the validity of the size of the sample statistically. The KMO value, which can have a value between 0 and 1, is interpreted as normal if it is between .5 and .7, as good if it is between .7 and .8, as very good if it is between .8 and .9 and as excellent if it is higher than .9 (Field, 2005). As a result of that process, the KMO value was calculated as .952. Since the calculated KMO value was higher than .9, it was considered that the size of the sample was highly acceptable.

Based on the results, the 8-factor solution accounted for the 79.278% of the variance (TPCK = 49.277, PCK = 9.749, CK = 5.700, PK = 4.396; TKW = 2.908, TK = 2.572, TCK = 2.238, TPK = 2.296). The total variance explained is 79.287%. The value of variance above 40% is claimed to be sufficient for social science studies (Gorsuch, 1983; Netemeyer et al., 2003). Therefore, the total variance explained found over 50% in this study could be said to be within the acceptable limits.

4.2 Confirmatory Factor Analyses

Confirmatory factor analysis was conducted to confirm the factor structure of the scale, based on the data from the second stratified random subsample ($n = 207$). In the study, Confirmatory Factor Analysis (CFA) was conducted with AMOS program in order to determine whether variable groups contributing to the factor in the 8-dimension CTPACK Scale as a result of the exploratory factor analysis were efficiently represented by these factors or not.

In evaluating the model fit, we supplement the model chi-square statistic with both absolute and incremental fit indices (Bentler & Bonnett, 1980; Hu & Bentler, 1998, 1999). Absolute fit indices evaluate how well an a priori model reproduces the sample data. We report the root mean square error of approximation (RMSEA) for which a value less than .06 indicates a good model fit (Hu & Bentler, 1999) and a value less than .08 suggests a reasonable model fit (Browne & Cudeck, 1992). The standardized root mean square residual (SRMR) is reported for which a value of .08 or lower indicates a good fit (Hu & Bentler, 1999). Incremental fit indexes evaluate model fit by comparing a target model to a baseline model. Typically, the null model in which all observed variables are uncorrelated is used as a baseline model. We report the comparative fit index (CFI), the Tucker–Lewis index (TLI), and the goodness-of-fit index (GFI), which have cutoff values close to .95 (Hu & Bentler, 1999). After examination of parameter estimates, fit indexes, and residuals, model modifications are conducted to the original hypothesized model to have better fitting or a more parsimonious model (Schreiber et al., 2006).

The result of the confirmative factor analysis revealed moderate model fit ($\chi^2 = 964.084$ [df = 594, $p < .001$], GFI = .804, CFI = .939, TLI = .931, SRMR = .051, RMSEA = .054 with a 90% interval of .048 to .060).

4.3 Reliability of the CTPCK Scores

The reliability of the scores of the CTPCK scale was determined by using Cronbach's alpha coefficient. Confidence intervals (95%) were also evaluated using the method recommended by Fan and Thompson (2001). According to Henson (2001) and Loo (2001), test scores should have reliabilities of .80 or better. The scores of the scales had acceptable reliability coefficients (see Table 1): $\alpha = .90$ (CK), $\alpha = .93$ (PK), $\alpha = .95$ (PCK), $\alpha = .93$ (TK), $\alpha = .85$ (TKW), $\alpha = .92$ (TPK), $\alpha = .91$ (TCK), and $\alpha = .91$ (TPCK).

Table 1 Description statistics and reliability coefficient for each subscale

Subscale	Number of items	Mean	SD	alpha
CK	4	3.99	1.19	.90
PK	5	4.62	1.10	.93
PCK	8	4.55	1.11	.95
TK	4	4.55	1.25	.93
TKW	3	5.11	1.32	.85
TPK	5	4.82	1.06	.92
TCK	4	4.48	1.14	.91
TPCK	4	4.45	1.13	.91

4.4 The Description and Analysis of TPACK

In this part, results concerning the perceptions of pre-service teachers' technological pedagogical content knowledge are presented. Table 2 also shows the mean scores of the 8 subscales, varied from 3.99 (SD = 1.19) for CK to 5.11 (SD = 1.32) for TKW. These results suggested that pre-service teachers had high perceptions about technological knowledge related to the World Wide Web and relative low perceptions about content knowledge.

Finally, A first picture of the nature of the relationships between the research variables can be derived from the results of the bivariate correlation analysis (see Table 2). For the purpose of this study, the correlations with TPCK are of primary interest. The results suggest high interrelationships among different variables. For instance, PCK is significantly related to TPCK ($r = .436$). TCK presented the strongest correlation with TPCK ($r = .726$).

Table 2. Correlations coefficients for pairs of variables (N = 436)

	{1}CK	{2}PK	{3}PCK	{4}TK	{5}TKW	{6}TPK	{7}TCK
{1}CK							
{2}PK	.576**						
{3}PCK	.495**	.596**					
{4}TK	.446**	.504**	.441**				
{5}TKW	.202**	.431**	.350**	.524**			
{6}TPK	.384**	.596**	.554**	.673**	.656**		
{7}TCK	.436**	.540**	.397**	.722**	.581**	.690**	
{8}TPCK	.490**	.552**	.436**	.679**	.489**	.688**	.726**

5. Discussion

In the past decennia, much research focusing on TPACK has been generated. An interesting and remarkable development of research on TPACK is that researchers have turned their attention from a messy construct to a layered construct within TPACK framework as presented in Figure 1. However, researchers have commented that the boundaries of the TPACK constructs can be at times be rather vague, making it difficult to categorize instances of ICT integration (Cox & Graham, 2009; Koehler & Mishra, 2008; Lee & Tsai, 2010).

Based on our findings, pre-service teachers were able to distinguish the overlapping construct such as the TCK, PCK and TPK which were reported to be problematic in prior studies such as Lee and Tsai (2010), Chai et al. (2010b) and Koh et al. (2010). The findings seem to suggest that when the TPACK framework is employed to survey pre-service teachers' perceived knowledge levels, consideration needs to be given to the specific type of pedagogical approaches they intend to employ (Chai et al., 2010b).

As reviewed by Lee and Tsai (2010), Web-based instruction has gained wide-reaching recognition among teacher educators and researchers in the area of educational technology, claiming that Web-based Instruction can provide learners with distant, interactive, individualized and inquiry-based learning activities (e.g., Lee & Tsai, 2005; Miller & Miller 2000; Tsai 2001). Hence force, in the present study, the breaking up of TK (of Mishra & Koehler, 2006) into two constructs of TK and TKW brings special concerns on "W" (the World Wide Web), in Chinese educational settings.

The reliability (Cronbach's alpha) coefficients for these factors were larger than .85, suggesting that these factors had highly sufficient reliability in assessing the pre-service teachers' TPACK.

6. Limitations and conclusions

The CTPCK has some limitations, which should be addressed in future research. A first limitation of our study was the limited sample of pre-service teachers considering the large population of their counterparts in China. Second, to develop the research instrument we randomly divided the original research sample in two subsamples. Hence, these two subsamples were not truly independent samples. In future research the modified model needs to be validated in an independent sample. Third, the appropriateness of the CTPCK should be assessed in a wider variety of contexts. Further refinement and evaluation of the CTPCK at other educational settings (e.g., school teachers) is needed. Finally, additional concurrent validity evidence is needed before the instrument is used extensively.

Building on the work of Lee and Tsai (2010), Chai et al., (2010a, 2011) and Koh et al. (2010), this study contributes to the extant study of TPACK through the creation of a survey with construct validity for all the seven TPACK constructs postulated by Mishra and Koehler (2006) and for one more construct related to knowledge about Internet. Both exploratory and confirmatory factor analyses verified reasonable and acceptable construction and validation of the scales. In conclusion, the acceptable internal consistency for the obtained dimensions and the strong correlation with related constructs support the notion that the CTPCK provides a useful measure to assess and describe pre-service teachers' technological pedagogical content knowledge.

References

- Angeli, C. & Valanides, N. (2005). Preservice elementary teachers as information and communication technology designers: an instructional systems design model based on an expanded view of pedagogical content knowledge. *Journal of Computer Assisted Learning*, 21, 292-302.
- Archambault, L., & Crippen, K. (2009). Examining TPACK among K-12 online distance educators in the United States. *Contemporary Issues in Technology and Teacher Education*, 9(1), 71-88.
- Barrera, E. (2004). Quality in virtual education environments. *British Journal of Educational Technology*, 35, 13-20.
- Becker, H. J. (2000). Findings from the teaching, learning and computing survey: is Larry Cuban right? *Educational Policy Analysis Archives*, 8, 1-32.
- Bentler, P. M., & Bonnett, D. g. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin*, 88, 588-606.
- Browne, M. W., & Cudeck, R. (1992). Alternative ways of assessing model fit. *Sociological Methods & Research*, 21, 230-258.

- Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2010a). Facilitating preservice teachers' development of technological, pedagogical, and content knowledge (TPACK). *Educational Technology & Society*, 13(4), 63-73.
- Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2010b). Exploring the Factor Structure of the Constructs of Technological, Pedagogical, Content Knowledge (TPACK). *Asia-Pacific Education Researcher* 20(3), 595-603.
- Chai, C. S., Koh, J. H. L., Tsai, C. C., & Tan, L. L. W. (2011). Modeling primary school pre-service teachers' Technological Pedagogical Content Knowledge (TPACK) for meaningful learning with information and communication technology (ICT). *Computer and Education*, 57, 1184-1193.
- Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2013). A Review of Technological Pedagogical Content Knowledge. *Educational Technology & Society*, 16(2), 31-51.
- Cox, S. & Graham, C. R. (2009) Diagramming TPACK in practice: using and elaborated model of the TPACK framework to analyze and depict teacher knowledge. *TechTrends*, 53, 60-69.
- Fan, X., & Thompson, B. (2001). Confidence intervals about score reliability coefficients, please: an ePM guidelines editorial. *Educational and Psychological Measurement*, 61, 517-531.
- Gorsuch, R. L. (1983). Factor analysis. Hillsdale, NJ: Lawrence Erlbaum.
- Hair, J. F., Black, W. C., Babin, B. J. & Anderson, R. E. (2010). Multivariate data analysis: A global perspective. (7th ed.). Upper Saddle River, NJ: Pearson.
- Henson, R. K. (2001). Understanding internal consistency reliability estimates: a conceptual primer on coefficient alpha. *Measurement and Evaluation in Counseling and Development*, 34, 177-189.
- Hu, L., & Bentler, P. M. (1998). Fit indices in covariance structural equation modeling: Sensitivity to underparameterized model misspecification. *Psychological Methods*, 3, 424-453.
- Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, 6, 1-55.
- Keating, T., & Evans, E. (2001). Three computers in the back of the classroom: preservice teachers' conceptions of technology integration. In J. Price, et al. (Eds.), *Proceedings of society for information technology & teacher education international conference 2001* (pp. 1671-1676). Chesapeake, VA: AACE.
- Koehler, M. J. & Mishra, P. (2005) What happens when teachers design educational technology? The development of technological pedagogical content knowledge. *Journal of Educational Computing Research*, 32, 131-152.
- Koehler, M. J., & Mishra, P. (2009). What Is Technological Pedagogical Content Knowledge?. *Contemporary Issues in Technology and Teacher Education (CITE Journal)*, 9(1), 60-70.
- Koh, J. H. L., Chai, C. S., & Tsai, C. C. (2010). Examining the technology pedagogical content knowledge of Singapore pre-service teachers with a large-scale survey. *Journal of Computer Assisted Learning*, 26(6), 563-573.
- Lee, M. -H., & Tsai, C. -C. (2005). Exploring high school students' and teachers' preferences toward the constructivist internet-based learning environments in Taiwan. *Educational Studies*, 31, 149-167.
- Loo, R. (2001). Motivational orientations toward work: an evaluation of the Work Preference Inventory (Student form). *Measurement and Evaluation in Counseling and Development*, 33, 222-233.
- Miller, S. M., & Miller, K. L. (2000). Theoretical and practical considerations in the design of web-based instruction. In B. Abbey (Ed.), *Instructional and cognitive impacts of web-based instruction* (pp. 156-177). Hershey, PA: Idea Group Publishing.
- Netemeyer, R., Bearden, W., & Sharma, S. (2003). Scaling procedures. Thousand Oaks, CA: Sage Publications.
- Pierson, M.E. (2001). Technology integration practice as a function of pedagogical expertise. *Journal of Research on Computing in Education*, 33, 413-430.
- Sahin, I. (2011). Development of survey of technological pedagogical and content knowledge (TPACK). *The Turkish Online Journal of Educational Technology*, 10(1), 97-105.
- Schmidt, D. A., Baran, E., Thompson, A. D., Koehler, M. J., Mishra, P., & Shin, T. (2009). Technological pedagogical content knowledge (TPACK): the development and validation of an assessment instrument for preservice teachers. *Journal of Research on Technology in Education*, 42(2), 123-149.
- Schreiber, J. B., Nora, a., Stage, F. K., Barlow, e. a., & King, J. (2006). Reporting structural equation modeling and confirmatory factor analysis: a review. *Journal of Educational Research*, 99, 323-337.
- Shulman, L. S. (1986). Those who understand: knowledge growth in teaching. *Educational Researcher*, 15, 4-14.
- Thompson, A. & Mishra, P. (2007). Breaking news: TPACK becomes TPACK! *Journal of Computing in Teacher Education*, 24, 38-39.
- Tsai, C. -C. (2001). The interpretation construction design model for teaching science and its applications to internet-based instruction in Taiwan. *International Journal of Educational Development*, 21, 401-415.
- Wallace, R. M. (2004). A framework for understanding teaching with the internet. *American Education Research Journal*, 41, 447-488.
- Voogt, J., Fisser, P., Pareja, Roblin, N., Tondeur, J., & van Braak, J. (2013). Technological pedagogical content knowledge – a review of the literature. *Journal of Computer Assisted Learning*, 29(2)109-121.
- Zhan, Y., & Ren, Y. Q. (2011). Improving TPACK of Mathematics pre-service teachers: an experimental research [培养数学专业师范生 TPACK 的实验研究]. *China Educational Technology [中国电化教育]*, 10, 15-23.

Effect of graphic design on E-book reading: A pilot eye-tracking study

Tse-Wen PAN^a, Ming-Chieh Hsu^b & Meng-Jung TSAI^{a*}

^a *Graduate Institute of Digital Learning and Education,*

National Taiwan University of Science and Technology, Taiwan

^b *Department of Information Communication, Yuan Ze University, Taiwan*

*mjtsai99@mail.ntust.edu.tw

Abstract: This study explored graphical design effects on learner's E-book control, visual behaviors and learning performance by a pilot eye-tracking experiment. Twelve university students with novice experience of Spanish language participated in an e-book reading task to learn basic Spanish vocabularies. All participants were randomly assigned into two groups of reading materials with high-related graphics and low-related graphics. During the experiment, an ASL MobileEye eye tracker was used to track and record the gaze data of learners into video files. After reading 10 sets of text-and-graphic vocabularies in the E-book through an iPad, each participant received an immediately posttest, a three-days and a one-week delayed posttest. Each participant's action controls and visual paths on the e-book were observed and coded. Mann-Whitney U tests, Wilcoxon tests and Pearson's correlation analyses were used to analyze the data. Results showed that the high-related-graphic group had significant higher scores on immediately posttest. In addition, students gained learning retentions in both groups. Regarding e-book control behavior, the high-related-graphic group clicked on sound buttons more than the other group. The learners who had happier prior language learning experience also tended to click more on pronunciation buttons. Besides, the learners who believed that graphic is helpful for learning vocabularies spent less time reading the e-book. This pilot study successfully demonstrated the usability of eye-tracking techniques to investigate students' eye fixations while reading e-books. Future study is suggested to explore the effects of e-book content design on students' reading behaviors or learning outcomes.

Keywords: E-book, reading, iPad, eye tracking, control behavior

1. Introduction

1.1 E-books

Since tablet computer has higher performance monitor, interactive features and can be used with internet, it becomes popular these years. Many representation formats of multimedia is used in E-book, such as text, text-speech, music, sound and animation (Korat & Shamir, 2008). In terms of the features of E-book, it includes hidden button, quick view, keyword searching and bookmark (Vassiliou & Rowley, 2008). On the other hand, the content of E-book form mobile device is more flexible and interesting than the content on the printed material (Woody, Daniel & Baker, 2010). In addition, Lin (2009) found that text-speech, animation, audio effects and highlighting futures of E-book enhances motivation of student while foreign language reading. However, Lam, Lam, Lam and McNaught (2009) found that students didn't enjoy in E-book reading and had very low scores on comprehension tests. Those inconsistent findings suggests researcher to explore deeply in this field.

1.2 Cognitive theory of multimedia

Cognitive theory of multimedia reported by Mayer (2009) was based on Dual-coding theory of Paivio. Mayer believes multimedia helps learner effectively while the material designer understanding the learning process of human. Multimedia content includes graphic and text in the same time, which is visual information and verbal information. Because human have sense of auditory and sense of sight,

graphic and text observed from different sense and enter to working memory area, by learner constructs the relation between graphic and text actively, combine with prior knowledge, and add the new knowledge into long-term memory.

Mayer advanced Coherence Principle, he believes multimedia material helps learning while interesting but non-related graphic and text are excluded. In the past findings, researchers found that interesting material can improve learning outcomes. However, according to cognitive theory of multimedia, non-related material may distract learner's attention and waste learner's time on non-related graphic, reducing information process in working memory and increase cognitive overload. Second, it may break the causal relationship between knowledge. Third, it may increase learner to integrate non-related graphic and prior knowledge.

Based on Mayer's (2009) cognitive theory of multimedia, adding non-related material reduce performance of memory and transfer of learner. On the other hand, non-related material increase more negative effects to learner who has lower working memory and lack of prior knowledge. Accordingly, Mayer concluded that multimedia material without unneeded pictures could bring better learning outcome.

1.3 Eye movement and reading

In the beginning of 1990's, visual attention application of reading and information processing eye movement research developed gradually. Eye-fixation is the natural reaction of visual stimulation, therefore visual attention observation and eye movement records are the better ways to understand the mental processes of reading and other visual activity of learner. In the other word, visual attention plays an important role of information process of human (Rayner, 1998). Previous researchers dedicated to exam the relation between eye movement record, different animation, sign, speed of material design and learner's prior knowledge, most of them prove visual attention examination result bring the insight for reading and cognitive activity. The current paper is a pilot eye tracking study to understand the reading and controlling behaviors of learners while learning from the E-book.

2. Purpose

This study aimed at examining the effects of multimedia design on student E-book visual and control behavior, a pilot eye tracking examination was used in this study. Specifically, this study explored how two different designs of graphic in the E-book (i.e., high-related graphic of the Spanish vocabulary and low-related graphic of the vocabulary) effect learning performance (i.e., posttests for Spanish vocabulary) and visual and control behavior (i.e., the total number of pronunciation clicking, the total time of E-book reading and the count of inter-scanning). This study further explored the relation between learners' background and reading behavior. The research questions included in following: RQ1: What are the effects of E-book graphical design on students' immediately learning achievement, retention and delayed retention? RQ 2: Is there any significantly difference in students' E-book reading behaviors between high-related and low-related graphic groups? And, if necessary, RQ 3: Is there any significant relationship between learners' backgrounds and reading behaviors?

3. Methods

Participants

This study engaged in purposive sampling. Twelve participants of this study were selected from a university of north Taiwan, with almost having no experience in learning Spanish (only one male had learning experience for one semester), and were randomly assigned into high-related graphic group or low-related graphic group. Participants in Low-related graphic group read low-related-graphic Spanish vocabulary E-book, while participants in high-related group read high-related-graphic E-book. Numbers of participants in each group is six, with five male participants and seven female participants.

With two damaged eye-tracking record data of low-related group, the six data of high-related group and four data of low-related group was analyzed in this study.

Learning material

The learning material in this study was an E-book of ten Spanish color vocabularies. Mayer' (2009) s Coherence Principle stated that students got higher learning outcomes with combining related graphic with text. On the contrary, text with interesting but non-related graphic could reduce the memory of important content of learner, and the score of the transfer test was worse than the high-related one. Therefore, two versions of learning material in this study included ten color vocabularies as follows, rojo (red), rosa (pink), naranja (orange), Amarillo (yellow), azul (blue), morado (purple), verde (green), negro(black), gris(gray), and marrón(coffee). As shown in Figure1, since apple is red, the graphic is high-related to the vocabulary “rojo (red)”. On the contrary, In Figure 2, the graphic is a man doing gymnastics; therefore it is low-related to the vocabulary. Participants of high-related graphic group read the E-book with high-related graphic to the text, as shown in Figure1. Meanwhile, participants of low-related graphic group read low-related graphic to the text, as shown in Figure 2. The content of E-book was presented by iPad, ten vocabularies was shown on each page. Two groups were the same in vocabularies and graphics were different, that is, high-related graphic and low-related graphic.

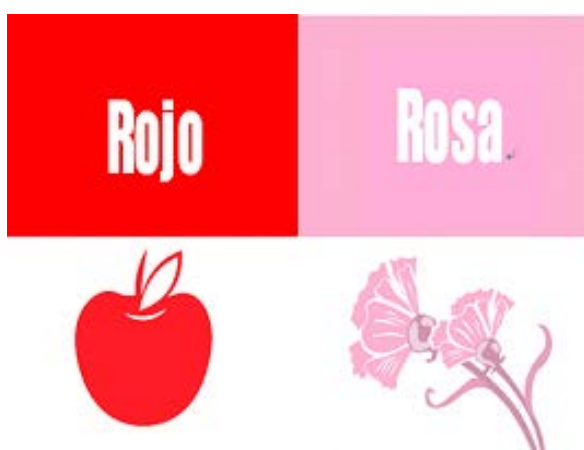


Figure1. Material for the high-related group.



Figure2. Material for the low-related group.

Eye-Tracking system

ASL Mobile Eye-XG with a sampling rate of 30 Hz was used to record participants' eye-movements through the reading process. It was free for participants to move their head. During the experiment, two cameras on the eye tracker recorded E-book control and reading behavior and participants' eye movement separately as the same time.

Background Questionnaire

The Background Questionnaire was developed for realizing the participants' language learning background; age, gender, the experiences and attitude of language learning, had experiences in learning Spanish or not, had experiences in using mobile devices assisting learning were included. The questionnaire was assessed through online Google docs questionnaire.

Posttest

The purpose of learning performance was to realize the differences of learning effect of participants between two groups after reading the material. Furthermore, to presume that if there was any difference learning effect between using high-related and low-related materials or not, the test question was edited by researcher and the professional Spanish teacher. There were twenty questions, and all questions were memory test, participants got five points for each correct answer. The content of the posttest was to

examine the vocabulary memory of participants. It separated into three parts: an immediately posttest and two delayed posttests after three days and one week after reading the material. All questions were distributed through online questionnaire with Google docs. The more scores the participants got, indicated the better learning effect they performed; the fewer scores they got, indicated the worse learning effect they performed.

Procedure

Twelve participants were randomly assigned into high-related graphic group and low-related graphic group. The procedure was:

1. Filled in the background questionnaire.
2. Wore the mobile-eye device and then processed calibration
3. Started to read Spanish color vocabulary E-book in iPad. The order of reading each page was not limited, and the maximum of total reading time is ten minutes.
4. After accomplish reading the E-book, participants received the first posttest immediately, the first delayed posttest is three days after reading the E-book; a week later, the second posttest was administered to participants.

Video Analyses

To observe E-book control and reading behavior of participants in different groups, the researchers counted two species of behavior by scenes video which included scan paths and gaze points from the eye tracker. Three behaviors were coding from videos, which were E-book control behavior and visual behaviors. The control behavior is total number of clicking pronunciation, which is defined as follows: the sum of participants' clicking on the pronunciation button in each page. On the other hand, visual behavior includes total reading time and inter-scanning count, which is defined as follows:

1. Total reading time: total time of participants to read the E-book.
2. Inter-scanning count: as shown in Figure 3, the cross mark means the gaze point of participant. While the cross mark on the text section, it indicates that the participant gaze at the text; in contrast, as shown in Figure 4, while the cross mark on the graphic section, it indicates that the participant gaze at the graphic. The scan path of "Text to graphic to text" or "text to graphic" was both counted as one time inter-scanning of text and graphic.

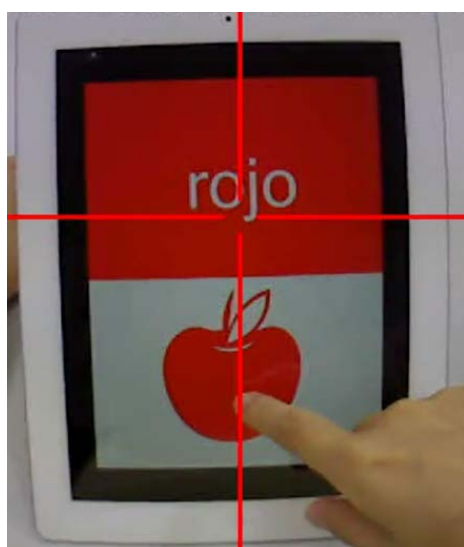


Figure 3. The participant gazes at the text.



Figure 4. The participant gazes at the graphic.

Statistical

In this study, Mann–Whitney U test was used to analysis the differences of three posttests and reading behavior between two groups. Besides, Wilcoxon test was used to analysis the retention of each posttest. Third, Pearson’s correlation was use to analysis participants’ background and reading behavior.

4. Results

Results of Mann–Whitney U test result on posttest scores

As shown in table 1, it’s found that there has high significantly different between high-related group and low-related group toward posttest1 and posttest2 scores (Cohen’s $d = 1.278$ and 1.111 respectively), the participants in high-related group get higher scores (Posttest1 mean = 91.25 , posttest2 mean = 88.75) than the participants in low-related group (Posttest1 mean = 75.00 , posttest2 mean = 71.25). In addition, the low significant different in the last posttest (Cohen’s $d = 0.474$), shows the scores of high-related group and low-related group are closer than both posttest1 and posttest2, the high-related group’s (Mean = 80.00) post-test2 scores is higher than the low-related group (Mean = 70.00). The mean of three posttests was shown in Figure 5; it means learners got lower scores on each posttests.

Table 1: Results of Mann–Whitney U test result on posttest scores between high and low related group.

	High-related			Low-related			z	p	Cohens’ d
	N	Mean	SD	N	Mean	SD			
Posttest1	4	91.25	11.09	4	75.00	14.14	-1.648	.099*	1.278 ^c
Posttest2	4	88.75	12.5	4	71.25	18.43	-1.423	.155	1.111 ^c
Posttest3	4	80.00	20.41	3	70.00	21.79	-0.178	.858	0.474 ^a

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Cohen’s d: ^a $0.2 < |d| < 0.5$; ^b $0.5 < |d| < 0.8$; ^c $0.8 < |d|$

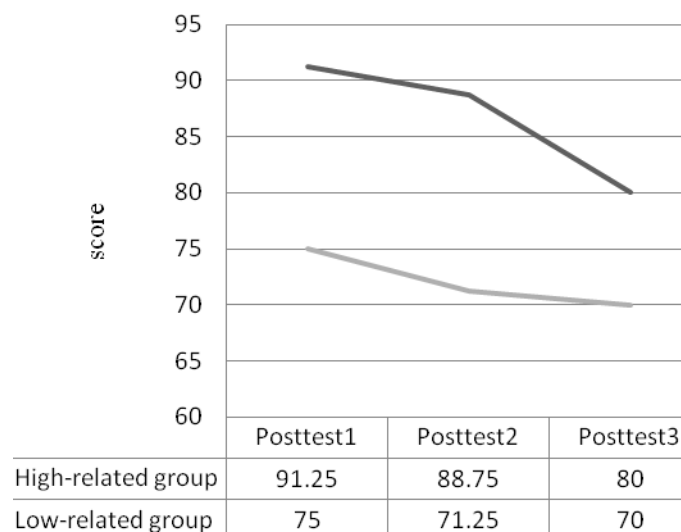


Figure 5.The line chart of average of three posttests.

Results of Wilcoxon test on posttest scores

As shown in Table 2 through the Wilcoxon test of different group found that there has no significant difference between high-related graphic group's and low-related graphic group's posttests. It indicated that the graphics of different relation have no significantly different toward learning retained.

Table 2: Results of Wilcoxon test on posttest scores.

	High-related					Low-related				
	N	Mean difference	SD	z	p	N	Mean difference	SD	z	p
Post1 - Post2	4	2.5	11.09	-1.414	.157	4	3.750	14.14	-.816	.414
Post2 - Post3	4	8.75	12.50	-1.604	.109	4	1.250	18.43	-1.342	.180
Post1 - Post3	4	11.25	20.41	-1.633	.102	3	5.000	21.80	-1.342	.180

*p < 0.1, **p < 0.05, ***p < 0.01

Results of Mann–Whitney U test result of E-book control and visual behavior

Table 3 and Figure 6 shows that different group Mann–Whitney U test result of reading behavior. It can be seen that pronunciation frequency of two groups have high significant difference (Cohen's d = 1.135). It indicates that the high-related group (Mean = 45.17) likes to click pronunciation better than the low-related group (Mean = 16.50). The high-related group trends to rely on clicking pronunciation. However, there is no difference between both total reading time and inter-scanning count in two groups.

Table 3: Results of Mann–Whitney U test result of E-book control and visual behavior.

	High-related				Low-related				z	p	Cohens' d
	N	Mean rank	Mean	SD	N	Mean rank	Mean	SD			
Total click number	6	6.67	45.17	34.5	4	3.75	16.50	9.15	-1.492	0.136	1.135 ^c
Total Reading Time	6	5.83	167.67	52.13	4	5.00	161.25	81.85	-.426	0.670	0.093
Inter-scanning count	6	5.50	40.00	17.16	4	5.50	39.25	13.72	0.000	1.000	0.048

*p < 0.1, **p < 0.05, ***p < 0.01

Cohen's d: ^a0.2 < |d| < 0.5; ^b0.5 < |d| < 0.8; ^c0.8 < |d|

Note: High-related = High-related group, Low-related = Low-related group

Total click number = the total number of clicking pronunciation, Total Reading Time = the total time of reading E-book, Inter-scanning = the number of inter-scanning

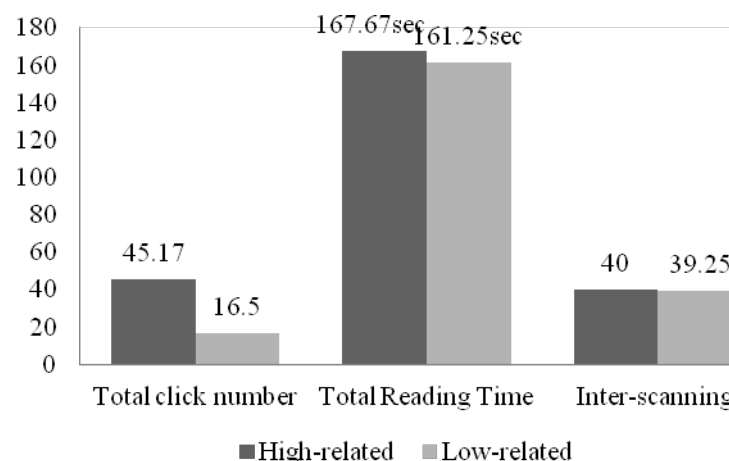


Figure 6. The column chart of average of three reading behaviors.

Correlation between participants' background and reading behavior

As shown in Table 4, happiness degree of learning English had significantly negative correlations with Pronunciation Frequency ($r=-0.723$, $p=.018$, $p<0.5$). This finding reveals that the students who have the happy experiences in learning English, they have lower frequency in click pronunciation. In other words, the participants who have the happy experiences in learning English seldom rely on sound resource.

In terms of, degree of how graphic helps while learning language had significantly negative correlations with Total Reading Time ($r=-0.671$, $p=.034$, $p<0.5$). It indicates that the participants of the opinion that graphics are useful for learning, they have less total reading time. On the contrary, the participants of the opinion that graphics aren't useful for learning, they have more total reading time.

Table 4: Correlation between participants' background and reading behavior.

	Happiness	TV	English Radio	Magazine	graphic helps
Total click number	-0.723**	0.181	0.323	0.060	-0.103
Total Reading Time	-0.393	0.123	-0.293	-0.399	-0.671**
Regression Frequency	-0.065	0.443	0.503	0.287	0.384

* $p < 0.1$, ** $p < 0.05$

Happiness= Happiness degree of learning English, TV= Frequency of watching English TV show, English Radio= Frequency of listening English Radio, Magazine= Frequency of reading English Magazine, graphic helps= Degree of how graphic helps while learning language

5. Discussion and conclusion

This study was conducted to investigate the effect of graphic design on E-book reading. We use Spanish vocabulary E-book as material, twelve adults was separated in high-related graphic group and low-related graphic group randomly. Three posttests scores and E-book control and visual behaviors—total number of clicking pronunciation, total time of reading E-book and the number of inter-scanning—was analysis. On the other hand, participants' background was also examined in the current study.

The first research question asked the effects of E-book graphical design on students' immediately learning achievement, retention and delayed retention. The result from Mann–Whitney U test showed that participants in high-related graphic group have not only significant higher score in immediately posttest but also in two delay posttests. This might imply that high-related graphic might be positive to learning outcome. This current finding is consistent to Mayer's (2009) Coherence Principle. On the other hand, Wilcoxon test analysis showed that there is no significant different in three posttests both in high-related graphic group and low-related graphic group. It could be inferred that the delayed retention wasn't be effect by different kinds of graphic.

The second research question asked is there any significantly difference in students' E-book reading behaviors between high-related and low-related graphic groups. The Mann–Whitney U test result showed that high-related graphic group has significant higher total number of clicking pronunciation. It might conjecture that high-related graphic could make more interaction when students read E-books.

The last research question asked is there any significant relationship between learners' backgrounds and reading behaviors. The correlation analysis result showed that participants who believe graphic is helpful while learning have significant lower total time of reading E-book. It might because that these graphics are learning paths for the participants who feel graphics are useful for learning, and they can grasp learning contents in less time. On the other hand, learners who had unhappy English learning experience have significant higher total number of clicking pronunciation.

In this study, the number of participants is small, future studies can further explore bigger samples to demonstrate the research result. Furthermore, the marital in the current study is language learning field, future study was suggested to explore different subjects.

References

- Korat, O., & Shamir, A. (2004). Do Hebrew electronic books differ from Dutch electronic books? A replication of a Dutch content analysis. *Journal of Computer Assisted Learning*, 20(4), 257-268. doi: 10.1111/j.1365-2729.2004.00078.
- Lam, P., Lam, S.L., Lam, J. and McNaught, C. (2009). Usability and usefulness of eBooks on PPCs: How students' opinions vary over time. *Australasian Journal of Educational Technology*, 25(1): 30–44.
- Lin, I. Y. (2009). The effects of e-books on EFL learners' reading attitude, (National Taiwan Normal University, Taiwan). Retrieved from <http://ndltd.ncl.edu.tw/cgi-bin/gs32/gswweb.cgi?o=dnclcdr&s=id=%22097NTNU5238009%22.&searchmode=basic>.
- Mayer, R. E. (2009). Multimedia learning (2ed ed.). New York: Cambridge University Press. *Journal of Computer Assisted Learning*, 20(4), 257-268.
- Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin*, 124(3), 372-422.
- Vassiliou, M., & Rowley, J. (2008). Progressing the definition of “e-book”. *Library Hi Tech*, 26(3), 355-368.
- Woody, W. D., Daniel, D. B. & Baker, C. A. (2010). E-books or textbooks: Students prefer textbooks. *Computers & Education*, 55(3), 945-948.

The relationships between master degree students' online academic information search behaviors and online academic help seeking

Ying-Ju CHIU* & Chin-Chung TSAI

Graduate Institute of Digital Learning and Education, National Taiwan University of Science and Technology, Taipei, Taiwan

*M10111003@mail.ntust.edu.tw

Abstract: The purpose of this study is to explore master degree students' online academic help seeking (OAHS) via their online academic information search behaviors (OAISB) and to compare their online academic help seeking between different groups. The participants were 386 master degree students in Taiwan, and we divided it into groups of major (science and non-science), including 210 science major samples and 176 non-science major samples. Take advantage of exploratory factor analysis, correlation analysis, and path analysis, this study found that some relationships existing between master degree students' online academic information search behaviors and their approaches to online academic help seeking. The results showed that the multiple sources as accuracy was a sufficiently reliable tool to assess master degree students' online academic help seeking. Non-science master degree students' deep as content could predict their using online resources appropriately but not science master degree students, content relevant to the goal might play a role in non-science master degree students' online academic help seeking.

Keywords: online, help seeking, searching evaluative standards

1. Introduction

In recent years, studying activities have been becoming more convenient and efficient because of the usage of the Internet, therefore, online academic help seeking has been growing into a tendency for adults' studying. Furthermore, researchers have expressed that help seeking is positive and beneficial for students during the past years (Lee, 2007). Cheng and Tsai (2011) exposed that students' functional web-based learning self-efficacy was related to their perceptions of information searching for online academic help seeking. As above, help seeking seemingly a fundamental portion in the studying process, and adults' self-standards of evaluation might play an important role in online academic help seeking. There were few research have paid attention to master degree students' online academic help seeking toward searching evaluative standards. Consequently, this study intends to explore the relationships between OAHS and OAISB of master degree students. To investigate the relationships between OAHS and OAISB may provide some ideas for future online academic articles searching system design.

2. Method

2.1 Participants

The participants of this study were 386 master degree students in Taiwan with no limits to major. The results of questionnaires were collected, 210 (54.4%) were major in science and 176 (45.6%) were major in non-science. The years they spent searching online academic articles was viewed as an indicator of their online academic help seeking. We only adopted those who have at least one experience

in online academic articles searching.

2.2 Instruments

For the purpose of investigating people's online academic information search behaviors and online academic help seeking, the instrument integrated questionnaires called online academic information search behaviors (OAISB) which was modified from Tsai's (2004) information commitments survey (ICS) and online academic help seeking (OAHS) developed by Cheng and Tsai (2011). And the developer were Wu and Liang (2013). ICS comprised three scales: (1) standards for accuracy, (2) standards for usefulness, and (3) searching strategy. OAHS were revised to assess the learners' learning environmental preferences and approaches to online academic help seeking. The rating range of the questions was from "strongly disagree" to "strongly agree" and was presented in a 1–5 Likert scale.

The OAISB survey aims to identify master degree students' online academic information search behaviors. There were six items including multiple sources as accuracy, authority as accuracy, deep as content, surface as content, usefulness as technical and usefulness as accessing. A detailed description for each scale is presented below:

- (1) Multiple sources as accuracy: Students evaluate the correctness of unknown online academic articles by comparing to other websites, printed texts or their prior knowledge.
- (2) Authority as accuracy: Students examine the correctness of unknown online academic article by the "authority" of the websites or sources such as a significant or famous journal.
- (3) Deep as content: Students evaluate the usefulness of academic articles through the detail content such as the abstract or results.
- (4) Surface as content: Students evaluate the usefulness of academic articles through the number of citations or downloads.
- (5) Usefulness as technical: Students evaluate the usefulness of academic articles through the ease of online retrieving or searching.
- (6) Usefulness as Accessing: Students evaluate the usefulness of academic articles through the purposeful ways of obtaining academic articles.

The OAHS survey aims to identify the behavior of online academic help seeking. There were four items including face to face as social network, online accessing as social network, using online resources appropriately and willingness. A detailed description for each scale is presented below:

- (1) Face to face as social network
- (2) Online accessing as social network
- (3) Using online resources appropriately
- (4) Willingness

3. Results

3.1 Factor analysis-Online academic information search behaviors (OAISB)

The results of the exploratory factor analysis indicated that six factors were extracted with a total of 24 items retained in the OAISB survey (shown in Table 1). Six factors of items correspond to Multiple sources as accuracy (3 items), Authority as accuracy (5 items), Deep as content (4 items), Surface as content (5 items), Usefulness as technical (3 items) and Usefulness as Accessing (4 items). The total variance of the factors is 61.66%. All eigenvalues of the six factors amount more than one, with the reliability (alpha) coefficients of the scales respectively at "Multiple sources as accuracy" (0.59), "Authority as accuracy" (0.88), "Deep as content" (0.72), "Surface as content" (0.81), "Usefulness as technical" (0.79) and "Usefulness as accessing" (0.68), overall alpha is 0.86, suggesting that these factors are sufficiently reliable for representing master degree students' online academic information search behaviors.

Table 1: Rotated factor loading and Cronbach's alpha values for the six subscales of the online academic information search behaviors (n=386).

	Factor1 MS	Factor2 AU	Factor3 DC	Factor4 SC	Factor5 UT	Factor6 UA
Factor 1: Multiple sources as accuracy (MS), $\alpha = 0.59$						
MS 2	0.58					
MS 3	0.79					
MS 4	0.76					
Factor 2: Authority as accuracy (AU), $\alpha = 0.88$						
AU 7		0.66				
AU 8		0.82				
AU 9		0.82				
AU 10		0.81				
AU 11		0.88				
Factor 3: Deep as content (DC), $\alpha = 0.72$						
DC 13			0.63			
DC 15			0.73			
DC 16			0.68			
DC 17			0.74			
Factor 4: Surface as content (SC), $\alpha = 0.81$						
SC 19				0.63		
SC 20				0.61		
SC 21				0.58		
SC 22				0.84		
SC 23				0.85		
Factor 5: Usefulness as technical (UT)), $\alpha = 0.79$						
UT 26					0.82	
UT 27					0.88	
UT 28					0.67	
Factor 6: Usefulness as Accessing (AT) $\alpha = 0.68$						
UA 29						0.66
UA 30						0.62
UA 32						0.69
UA 34						0.69

Notes: Loadings less than 0.50 omitted.

Overall alpha: 0.86.

Total variance explained: 61.66%.

3.2 Factor analysis - Online Academic Help Seeking (OAHS)

The results of the exploratory factor analysis indicated that four factors were extracted with a total of 12 items retained in the OAHS survey (shown in Table 2). Four factors of items correspond to Face to face as social network (3 items), Online accessing as social network (3 items) , Using online resources appropriately (3 items) and Willingness (3 items). The total variance of the factors is 61.66%. All eigenvalues of the four factors amount morethan one, with the reliability (alpha) coefficients of the scales respectively at “Face to face as social network” (0.69), “Online accessing as social network” (0.72), “Using online resources appropriately”(0.68) and “Willingness” (0.62), overall alpha is 0.86., suggesting that these factors are sufficiently reliable for master degree students'representing online academic help seeking.

Table 2: Rotated factor loading and Cronbach's alpha values for the four subscales of the online academic help seeking (n=386).

	Factor1 FS	Factor2 OS	Factor3 US	Factor4 WI
Factor 1 :Face to face as social network(FS), $\alpha= 0.69$				
FS 35	0.75			
FS 36	0.87			
FS 37	0.72			
Factor 2:Online accessing as social network (OS) , $\alpha= 0.72$				
OS 41		0.89		
OS 42		0.91		
OS 44		0.54		
Factor 3:Using onlineresources appropriately(US) , $\alpha= 0.68$				
US 46			0.75	
US 47			0.71	
US 48			0.83	
Factor 4:Willingness (WI) , $\alpha= 0.62$				
WI 49				0.69
WI 50				0.77
WI 51				0.71

Notes: Loadings less than 0.50 omitted.

Overall alpha: 0.73.

Total variance explained: 64.05%.

3.3 Correlations between OAISB and OAHS

Table 3 summarizes the results of correlation analysis between online academic information search behaviors and online academic help seeking. It was found that all factors of OAHS were significantly correlated with the factor of multiple sources as accuracy, and all factors of OAISB were significantly correlated with the factor of face to face as social network. That is to say, master degree students tend to acquire academic articles by face to face. When master degree students need academic help seeking, they would like to choose multiple sources as accuracy.

Table 3: Correlations between online academic information search behaviors and online academic help seeking. (n=386)

	MS	AU	DC	SC	UT	UA
FS	0.22***	0.14**	0.17***	0.11*	0.11*	0.12*
OS	0.19***	0.08	-0.51	0.17***	0.04	0.30
US	0.34***	0.04	0.28***	0.14	0.13**	0.23***
WI	0.21***	0.08	-0.00	0.69	0.00	0.42

Notes: * $p < 0.05$, ** < 0.01 , *** < 0.001 .

MS: Multiple sources as accuracy, AU: Authority as accuracy, DC: Deep as content, SC: Surface as content, UT: Usefulness as technical, UA: Usefulness as accessing, FS: Face to face as social network, OS: Online accessing as social network, US: Using online resources appropriately, WI: Willingness.

3.4 Path analysis of major difference in OAISB and OAHS

Major in science

The path analysis revealed that multiple sources as accuracy of OAISB were the predictor for all the factors of OAHS. Face to face as social network ($\beta = 0.27$, $p < 0.001$), online accessing as social network

($\beta = 0.26$, $p < 0.001$), using online resources appropriately ($\beta = 0.26$, $p < 0.001$), and willingness ($\beta = 0.21$, $p < 0.01$). Multiple sources as accuracy might play an important role in OAHS for science master degree students. Authority as accuracy of OAISB would be predictors to face as social network of OAHS ($\beta = 0.16$, $p < 0.05$), in other words, when searching the authoritative academic articles, science master degree students might tend to get it face to face. Surface as content of OAISB would be predictors to online accessing as social network of OAHS ($\beta = 0.24$, $p < 0.01$), science master degree students those pay attention to impact factor of articles might tend to access articles online. Usefulness as Accessing of OAISB would be reverse predictors to online accessing as social network ($\beta = -0.17$, $p < 0.05$) of OAHS, science master degree students only used the online articles which beneficial for them by evaluating.

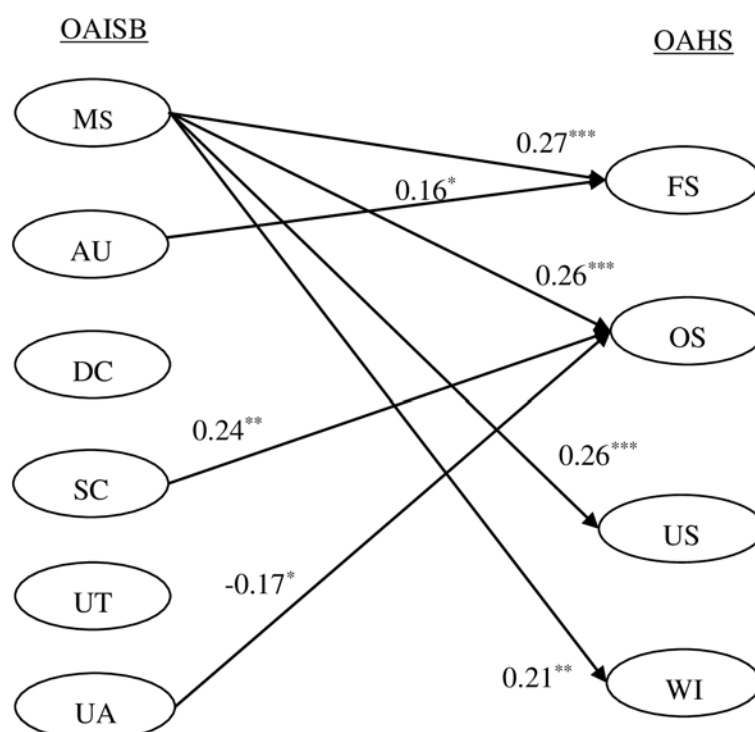


Figure 1. Path analysis for science master degree students (n=210).

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

MS: Multiple sources as accuracy, AU: Authority as accuracy, DC: Deep as content, SC: Surface as content, UT: Usefulness as technical, UA: Usefulness as accessing, FS: Face to face as social network, OS: Online accessing as social network, US: Using online resources appropriately, WI: Willingness.

Majorin non-science

The path analysis found that non-science master degree students' multiple sources as accuracy of OAISB would be predictors to the greater part of OAHS except face to face as social network. Online accessing as social network ($\beta = 0.17$, $p < 0.05$), using online resources appropriately ($\beta = 0.21$, $p < 0.01$), and willingness ($\beta = 0.22$, $p < 0.01$). The reason probably would be that non-science master degree students' less seeking other people's help when searching academic articles. Deep as content of OAISB would be a predictor to using online resources appropriately of OAHS ($\beta = 0.25$, $p < 0.01$), we could infer that non-science master degree students those pay attention to content of articles might tend to access articles online appropriately. Surface as content of OAISB would be predictors to online accessing as social network ($\beta = 0.19$, $p < 0.05$) and using online resources appropriately ($\beta = 0.19$, $p < 0.05$) of OAHS, non-science master degree students those pay attention to impact factor of articles might tend to access articles in person. Usefulness as accessing of OAISB would be reverse predictors to online accessing as social network of OAHS ($\beta = 0.18$, $p < 0.05$), non-science master degree students

used the online articles which beneficial for them by evaluating might tend to adopt online resources appropriately.

Non-science master degree students' deep as content could predict their using online resources appropriately but not science master degree students. The results could be referred to the non-science students emphasis more in if the content relevant to the goal during they were searching.

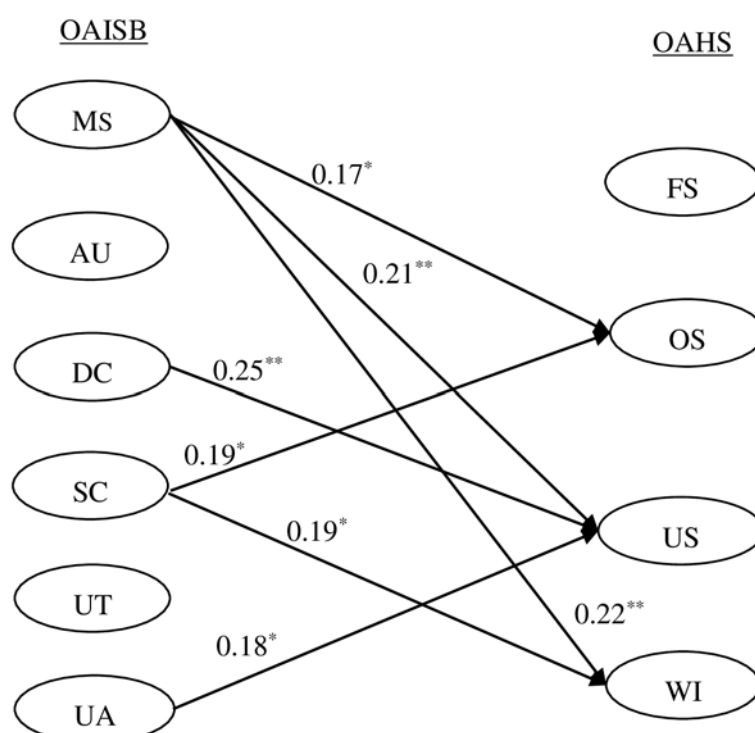


Figure 2. Path analysis for non-science master degree students (n=176).

Notes: * $p < 0.05$, ** < 0.01 , *** < 0.001 .

MS: Multiple sources as accuracy, AU: Authority as accuracy, DC: Deep as content, SC: Surface as content, UT: Usefulness as technical, UA: Usefulness as accessing, FS: Face to face as social network, OS: Online accessing as social network, US: Using online resources appropriately, WI: Willingness.

Both science and non-science master degree students, usefulness as technical of OAISB could not predict any OAHS factor, the reason might be those master degree students have lower evaluative standards. These results show that multiple sources as accuracy is one of the main predictor toward master referred students' OAHS, the reason might be those master degree students needs to be the multi-verification before accessing academic articles were much proactive. Non-science master degree students' deep as content could predict their using online resources appropriately but not science master degree students. The results could be referred to the non-science students emphasis more in if the content relevant to the goal during they were searching.

References

- Tsai, C.-C. (2004). Information commitments in Web-based learning environments, *Innovations in Education and Teaching International*, 41(1), 105-112.
- Lee, C.-J. (2007). Academic help seeking: Theory and strategies for nursing faculty. *The Journal of Nursing Education*, 46(10), 468-475.
- Cheng, K.-H., & Tsai, C.-C. (2011). An investigation of Taiwan University students' perceptions of online academic help seeking, and their web-based learning self-efficacy. *The Internet and Higher Education*, 14(3), 150-157.
- Wu, J.-C., & Liang, J.-C. (2013). Graduate students' online academic information search behaviors in Taiwan. Paper presented at International Conference on Computers in Education (ICCE2013), Indonesia.

Graduate students' online academic information search behaviors in Taiwan

Jui-Chi WU ^{a*} & Jyh-Chong LIANG^a

^a Graduate Institute of Applied Science and Technology, National Taiwan University of Science and Technology, Taiwan

*remywu567@gmail.com

Abstract: Previous studies have found out that students' search evaluating standards and search strategies play an important role in online information searching. Some studies indicated that there are only few studies discuss about graduate students' online academic information search behaviors. Therefore, this study was conducted to assess these students' online academic information search behaviors including search evaluating standards and search strategies. The interview findings were as a foundation to develop Online Academic Information Search Behaviors (OAISB) inventory, and then to explore the relationships between search evaluating standards and search strategies. The participants in this study included 296 graduate students in Taiwan. Results showed that the students with elaboration higher-level search strategies expressed multiple sources, deep as content, usefulness as technical and accessing as technical. And match lower-level search strategies attempt authority, surface as content, usefulness as technical and accessing as technical. In addition, the regression analyses revealed that graduate students' online academic information search evaluating standards were viewed as predictors to explain their search strategies.

Keywords: Academic information, search evaluating standards, search strategies.

1. Introduction

Searching and using information from different websites has been normally moved into our daily life. There are abundant resources in the online database for users to utilize. Many studies indicated that information searching has become one of the common and frequent online activities in our daily lives (Meneses, Boixados, Valiente, Vivas, & Armayones, 2005). Particularly, students usually look for information on the web to complete their learning tasks during the learning process. Online databases can provide students with more information than traditional books and tools (Lee & Tsai, 2011). Studies also indicated that the Internet has become the primary resource when graduate students and researcher prepare their paper writings (Barrett, 2005; Griffiths & Brophy, 2005; Liu & Yang, 2004). Therefore, to judge the web information is getting more important.

How learners to judge online information has become an important issue. In the process of the information seeking, students may use various types of search strategies to achieve what they desire to complete academic tasks on the Internet (Tsai & Tsai, 2003; Wu & Tsai, 2007). In 2004, Tsai proposed a theoretical framework for web user's information commitments, which included three aspects: standards for accuracy, standards for usefulness, and searching strategy, and also it can be consisted of six factors of representing of information commitments, including "multiple sources as accuracy," "authority as accuracy," "content as usefulness," "technical issues as usefulness," "elaboration as searching strategy," and "match as searching strategy." It was concluded that "Multiple sources," "Content," and "Elaboration" were advanced information commitments, while the others were viewed as less sophisticated by Tsai (2004). However, there is a great deal of academic information on the Internet, so it may become a problem of information over load for researchers. Head (2007) found that graduate students could not find what they need in plenty of relevant academic information in their research fields. The academic information search evaluating standards and search strategies are getting more significant for students. Hence, learner' and researchers' online academic research processes and behaviors have been focused on by many researchers (Du & Evans, 2011).

Literature process could be easily ignored by researchers (Rempel, 2010). Not only for researchers but graduate students, learning how to do search and evaluate literature reviews is an important training process. Yet, as indicated by Boote and Belie (2005), students oftentimes less focused on the literature review process and stressed more on the adoption of methodology and interpretations of gained results. This unbalanced emphasis may not be able to secure the appropriateness of their studies. Nowadays, many studies have found out that students' search strategies and evaluating standards play an important role on literature searching and using (Head, 2007; Ismail & Kareem, 2011). Some studies indicated that there are only few studies discuss about graduate students' academic information seeking behavior (Barrett, 2005; Chu & Law, 2008). Therefore, it is fundamental and quit significant to know what graduate students' literature search evaluating standards and search strategies.

In this study, we attempted to initially understand graduate students' online academic information search behaviors including search evaluating standards and search strategies. Through gathering the interview data from the participants, the results of qualitative analysis could serve as a foundation to develop an inventory, and then gathering questionnaire data randomly from graduate students in Taiwan. Moreover, the relationships between online academic information search evaluating standards and search strategies are investigated.

This study was undertaken to investigate the following research questions:

- Through exploratory factor analyses, could the developed questionnaires in this study, Online Academic Information Search Behaviors, be adequate tools to probe the graduate students' search evaluating standards and search strategies?
- What are the relationships between graduate students' online academic information search evaluating standards and search strategies?
- Through regression analysis, could graduate students' online academic information search evaluating standards be used to make significant predictions about their search strategies?

2. Methodology

Participants

The participants included 296 volunteer students in Taiwan. They were randomly from different universities across various demographic areas in Taiwan. There were 164 male and 132 female students, and they came from different and specific backgrounds including different faculties of the interviewees such as faculty of management, faculty of electrical engineering and computer science, faculty of education and faculty of life science. The age of the students was from 22 to 49 with an average age of 25.18.

Instruments

According to the interview findings to develop the questionnaire, namely Online Academic Information Search Behaviors (OAISB) is based on the structure of Information Commitment Survey (ICS) in Wu and Tsai's (2005) study. Wu and Tsai (2005) found six factors of ICS, four factors were search evaluating standards and two categories were search strategies. These served as the foundation for the development of the OAISB inventory.

However, according to interview findings, the factors of search evaluating standards were divided from four into six factors, which are "Multiple sources," "Authority," "Deep as content," "Surface as content," "Usefulness as technical" and "Usefulness as accessing." And, the factors of search strategies keep in two the same factors, "Elaboration" and "Match," correspondingly. The total of OAISB inventory concluded eight factors including search evaluating standards and search strategies. Four to seven items for each of the six factors of online academic information search evaluating standards were constructed, accordingly. And nine items of each of two factors of academic information search strategies were constructed. Finally, a 52-item, six-factor of evaluating standards and two-factor of search strategies initial version of OAISB was established.

The pilot of inventory verification tested the inventory using 296 graduate students, which enabled further examination of the structure, reliability and validity of OAISB. Participants were asked

to rate their agreement with the items on a five-point Likert scale (1=strongly disagree to 5=strongly agree). The inventory included the following eight factors, with an interview finding and a sample item for each factor:

- Multiple sources: Students evaluate the correctness of unknown online academic articles by comparing to other websites, printed texts or their prior knowledge.
An interview finding: *...yes, if the content of article is what I have learned before, I think it is right and it is believable.*
A sample item of this factor: If the content matches the knowledge that I have learned, I think the article is correct.
- Authority: Students examine the correctness of unknown online academic article by the “authority” of the websites or sources such as a significant or famous journal.
An interview finding: *...mostly I chose higher significant journal to search articles because the level of journal is been inspected, so that is why it can be trust.*
A sample item of this factor: If the article is accepted by a significant journal (e.g., SSCI; SCI; IEEE), I think it is correct.
- Deep as content: Students evaluate the usefulness of academic articles through the detail content such as the abstract or results.
An interview finding: *...check its input and output... to check is it what I want...the point is the result of the article and its process.*
A sample item of this factor: If the result of the study in the abstract is what I want, I think the article is useful.
- Surface as content: Students evaluate the usefulness of academic articles through the number of citations or downloads.
An interview finding: *...if I have not read the full article yet, I think I will take a look at the number of citations, for example if there are many articles refer to it, it means it is worth to read it.*
A sample item of this factor: If the number of citations of the article is high, I think it is useful.
- Usefulness as technical: Students evaluate the usefulness of academic articles through the ease of online retrieving or searching.
An interview finding: *...on the left side of the database, there are many options we can choose such as education field, engineering field, computer science field etc., we can check one of them and go searching.*
A sample item of this factor: If the database is classified and sorted in a very organized way, I will use it to search for literature.
- Usefulness as Accessing: Students evaluate the usefulness of academic articles through the purposeful ways of obtaining academic articles.
An interview finding: *...the format is the most important thing, like what I said, sometimes when I could not find the PDF, I feel anxious.*
A sample item of this factor: If the format is what I desire (e.g., PDF) when downloading articles, I think the literature in the database is useful.
- Elaboration: Students who have purposeful searching and thinking to integrate academic information from different sources to achieve their purposes.
An interview finding: *...if I found the topic has been doing by many people and their methods are better than mine, I will give up this topic.*
A sample item of this factor: I compare different academic information from relevant academic websites.
- Match: Students who use only few keywords to find a website or just view the first websites which contain the most abundant and relevant academic information.
An interview finding: *... I rely on what the search engine match the keywords I have given, is it match what the keywords I am looking for.*
A sample item of this factor: I just want to find an academic website which has the most useful academic information.

Data analysis

The pilot study used principle component analysis to clarify the factor structure of OAISB respectively. Then the alpha coefficient for each factor of the inventory was calculated to ensure the reliability of

each factor. The Pearson correlation was utilized to explore the relationship between online academic information search evaluating standards and search strategies. Moreover, a stepwise regression model was built by using the categories of search evaluating standards as predictors, and the categories of search strategies were regarded as the outcome variable.

3. Results and Discussion

Factor analysis

OAISB was through gathering the interview data to develop as an inventory for graduate students; hence, this study utilized exploratory factor analysis to examine the factor structure and the reliability of the factor in this new survey. The factor analysis of the OAISB, shown in Table 1, revealed that graduate students' response on the survey were grouped into eight factors (33 items), that is "Multiple sources," "Authority," "Deep as content," "Surface as content," "Usefulness as technical," "Usefulness as accessing," "Elaboration," and "Match." Different from previous studies (e.g. Tsai, 2004; Wu & Tsai, 2005; 2007), the factors were divided from six factors to eight factors that originally "standards for usefulness" were including two factors, "content" and "technical," however, in this study these two factors extended to four factors namely "Deep as content," "Surface as content," "Usefulness as technical," "Usefulness as accessing." These eight factors accounted for 62.54% of the variance. The reliability coefficients (Cronbach's alpha value) for each factor were around 0.64 – 0.89, and the overall alpha was 0.87, suggesting that the internal consistency of OAISB inventory with these eight factors was sufficient for statistical analysis.

Students' scores on the factors

The students' mean scores on each factor of the OAISB is shown in Table 1, all the students' mean scores on each factor were all larger than 3 points on a five-point scale, except of the "Match" (an average of 2.68 per item) factor, which was lower than the theoretical mean of the five-point Likert scale (i.e., 3). The students attained the highest scores on the "Deep as content" factor (an average of 4.03 per item), and followed by the factor "Multiple sources" (an average of 3.91 per item) and the factor "Elaboration" (an average of 3.88 per item). The results imply that graduate students tended to show stronger agreement with higher-level online academic information search behaviors. They attempted to search online academic articles from multiple sources and read details of content as search evaluating standards, in addition, to elaborate the academic information from different web sources.

Table 1: Rotated factor loadings and Cronbach's alpha values for the eight factors of the Online Academic Information Searching Behaviors (n=296).

	Factor 1: MS	Factor 2: AU	Factor 3: CONd	Factor 4: CONs	Factor5: TECHd	Factor6: TECHs	Factor7: ELA	Factor8: MAT
Factor 1 : Multiple Sources (MS), $\alpha=0.64$, mean=3.91, S.D.=0.46								
MS_2	0.58							
MS_3	0.75							
MS_4	0.77							
Factor 2 : Authority (AU), $\alpha=0.89$, mean=3.54, S.D.=0.66								
AU_7		0.70						
AU_8		0.83						
AU_9		0.83						
AU_10		0.84						
AU_11		0.89						
CONd_18		0.54						
Factor 3 : Deep as Content (CONd), $\alpha=0.73$, mean=4.03, S.D.=0.45								
CONd_13			0.63					

CONd_15	0.68	
CONd_16	0.67	
CONd_17	0.72	
Factor 4 : Surface as Content (CONs), $\alpha=0.81$, mean=3.31, S.D.=0.63		
CONs_19	0.66	
CONs_20	0.63	
CONs_21	0.54	
CONs_22	0.77	
CONs_23	0.80	
Factor 5 : Usefulness as Technical (TECHd), $\alpha=0.79$, mean=3.78, S.D.=0.69		
TECHd_26	0.86	
TECHd_27	0.88	
TECHd_28	0.58	
Factor 6 : Usefulness as Accessing (TECHs), $\alpha=0.70$, mean=3.74, S.D.=0.67		
TECHs_32		0.59
TECHs_33		0.76
TECHs_34		0.82
Factor 7 : Elaboration (ELA), $\alpha=0.78$, mean=3.88, S.D.=0.53		
ELA_4		0.65
ELA_6		0.57
ELA_7		0.74
ELA_8		0.79
ELA_9		0.73
Factor 8 : Match (MAT), $\alpha=0.72$, mean=2.68, S.D.=0.69		
MAT_12		0.66
MAT_13		0.74
MAT_15		0.69
MAT_16		0.73

Loadings less than 0.50 were omitted. Overall $\alpha = 0.87$; total variance explained = 62.54%.

Correlation between online academic information search evaluating standards and search strategies

Table 2: The correlation between the factors of the Online Academic Information Search Evaluating Standards and Search Strategies (n=296).

	MS	AU	CONd	CONs	TECHd	TECHs
Elaboration	0.42***	0.11	0.32***	0.09	0.20**	0.26***
Match	-0.14*	0.18**	0.05	0.34***	0.23***	0.13*

***: $p < .001$, **: $p < .01$, *: $p < .05$;

MS: Multiple Sources, AU: Authority, CONd: Deep as Content, CONs: Surface as Content, TECHd: Usefulness as Technical, TECHs: Usefulness as Technical.

The Pearson's correlation was used to reveal the relationships between the factors of search evaluating standards and search strategies. The results are presented in Table 2. It was found that the students with elaboration search strategy tended to express search evaluating standards such as "Multiple sources," "Deep as content," "Usefulness as technical," and "Usefulness as Accessing." On the other hand, the students with match search strategy not tended to possess the "Multiple sources" search evaluating standard, and tended to have search evaluating standards such as "Authority," "Surface as content," "Usefulness as technical," and "Usefulness as accessing." In general, the results showed that the

students' higher-level search strategy as elaboration was associated with higher-level of search evaluating standards such as "Multiple sources," "Deep as content." Meanwhile, lower-level search strategy as match was attempt to have lower-level of search evaluating standards such as "Authority," and "Surface as content." However, both evaluation and match search strategies were expressed technical no matter "Usefulness as technical," or "Usefulness as accessing."

Stepwise regression analysis for predicting students' online academic information search strategies by search evaluating standards

This study conducted a series of stepwise multiple regression analyses to predict students' online academic information search strategies. The students' online academic information search evaluating standards were used as predictors, and their search strategies were outcome for the analyses. The results are shown in Table 3. As a result, the students' online academic information search evaluating standards such as "Multiple Sources," ($t=6.35$, $p<0.001$) "Deep as Content," ($t=3.13$, $p<0.01$) and "Accessing as Technical" ($t=2.78$, $p<0.01$) were significantly positive predictors of higher-level elaboration search strategy. The students' "Multiple Sources," ($t= -3.67$, $p<0.001$) "Surface as Content," ($t=5.61$, $p<0.001$) and "Usefulness as Technical" ($t=3.25$, $p<0.01$) were predictors of lower-level match search strategy.

Based on the analysis of the data in Table 3, it is found that students' higher-level of search evaluating standards (i.e., "Multiple Sources," and "Deep as Content") played an important role in elaboration search strategy. In addition, technical is quite important for both search strategies such as "Elaboration" and "Match." The students' "Technical as accessing," to access academic articles, could predict the higher-level elaboration search strategy. Meanwhile, "Usefulness of technical," through the ease of retrieving academic articles, could predict the lower-level match search strategy.

Table 3: Stepwise regression model of predicting students' online academic information search strategies by search evaluating standards factors (n=296).

OAIS scale	Predictor(s)	B	S.E.	Beta	t	R ²
Elaboration	Multiple Sources	0.39	0.06	0.34	6.35***	0.23
	Deep as Content	0.20	0.07	0.17	3.13**	
	Accessing as Technical	0.12	0.04	0.15	2.78**	
	Constant	1.08	0.30		3.55***	
Match	Multiple Sources	-0.30	0.08	-0.20	-3.67***	0.16
	Surface as Content	0.34	0.06	0.31	5.61***	
	Usefulness as Technical	0.18	0.06	0.18	3.25**	
	Constant	2.03	0.37		5.45***	

***: $p<0.001$, **: $p<0.01$, *: $p<0.05$.

Acknowledgements

We would like to thank all the people who prepared and revised previous versions of this document.

Selected References

- Barrett, A. (2005). The information-seeking habits of graduate student researchers in the humanities. *Journal of Academic Librarianship*, 31, 324-331.
- Du, J. T., & Evans, N. (2011). Academic Users' Information Searching on Research Topics: Characteristics of Research Tasks and Search Strategies. *The Journal of Academic Librarianship*, 37(4), 299-306.
- Liang, J.-C., & Tsai, C.-C. (2009). The information commitments toward web information among medical students in Taiwan. *Educational Technology & Society*, 12, 162-172.
- Tsai, C.-C. (2004). Information commitments in Web-based learning environments. *Innovations in Education and Teaching International*, 41(1), 105-112.
- Wu, Y.-T., & Tsai, C.-C. (2005). Information commitments: evaluative standards and information searching strategies in web-based learning environments. *Journal of Computer Assisted Learning*, 21, 374-385.
- Wu, Y.-T., & Tsai, C.-C. (2007). Developing an Information Commitment Survey for assessing students' web information searching strategies and evaluative standards for web materials. *Educational Technology & Society*, 10, 120-132.

The Relationships between Taiwan University Students' Internet Attitudes and Their Preferred Teacher Authority toward Internet-based Learning Environments

Tzung-Jin LIN^{a*} & Min-Hsien LEE^b

^a Graduate Institute of Applied Science and Technology, National Taiwan University of Science and Technology, Taiwan

^b Institute of Education, National Sun Yat-sen University, Taiwan

*D9822302@mail.ntust.edu.tw

Abstract: Although the issue of teacher authority in the Internet-based learning environments has begun to gain attention recently, the relation with students' Internet attitudes is still unclear. Since a more appropriate attitude toward the Internet is required for successful Internet-based instruction, this study aimed to initially explore the relationships between students' Internet attitudes and their preferences of teacher authority in the Internet-based learning environments. A total of 259 Taiwan undergraduates were invited to complete two instruments to assess their preferences of teacher authority in the Internet-based learning environments and Internet attitudes, respectively. Through exploratory and confirmatory factor analysis, the two adopted instruments showed satisfactory validities and reliabilities. Moreover, the path analysis results indicate that, if the students prefer learner-centered process authority, they tend to possess positive Internet attitudes. For example, they may view the Internet more useful, possess higher confidence when using the Internet, and use the Internet more frequently. On the contrary, if the students show their preferences for a teacher-centered content authority, they are prone to use the Internet more often.

Keywords: Internet attitudes, Teacher authority, Internet-based learning environments

1. Introduction

Internet-based learning has been recognized an effective way to promote students' learning. When constructing the Internet-based learning environments, it is imperative for researchers to know students' preferences toward these environments. Although a handful of researchers have explored this issue (e.g., Yang & Tsai, 2008), it is claimed here that a more detailed scrutiny may be needed. For example, studies have indicated that implementing a successful Internet-enhanced learning environment depends not only on the design of the system but also on the role of instructors (e.g., Lin et al., 2012). In other words, in order to successfully implement Internet-based instruction, how students envisage the role of teacher in the Internet-based learning environments may be of importance to explore in this line of research. Under this circumstance, the extent of teachers' control over practices in the Internet-based learning environments may be imperative to influence students' preferences or perceptions toward these environments. In the traditional learning environments, the issue of teacher authority has gained much attention lately (e.g., Lee et al., 2009). Yet, in the context of Internet-based learning, this issue has not been fully understood. Recently, Lin et al. (2012) proposed that teacher authority can be conceptualized as a three-dimensional of authority including content authority (e.g., what and who determine the learning content), process authority (e.g., the control of classroom procedures and activities), and intellectual authority (e.g., the ways of what counts as knowledge and who is validated as knower). It is expected that, due to the unique features of Internet-based learning environments, the transition of teacher authority that shifts from teachers to students may occur.

In addition, since the rapid development of Internet technology in education, numerous studies have investigated how students' characteristics contribute to learning in the Internet-based context.

They also claimed that it is the fundamental step to be aware of students' preferences toward Internet-based learning environments. Among those unique characteristics within learners, Internet attitude may be one of the crucial elements. There is no doubt that a more positive attitude toward the Internet is required for successful Internet-based learning and instruction (e.g., Tsai et al., 2001). As documented in the literature, students' positive attitudes toward the Internet may influence their learning behaviors, motivations, interests, and outcomes relative to Internet-based learning (e.g., Peng et al., 2006). However, it is argued here that the relationships between students' preferences of teacher authority in the Internet-based learning environments and their Internet attitudes are still unclear. In turn, the present study aimed to extend the current understanding regarding the relationships between students' Internet attitudes and their preferences of teacher authority in the Internet-based learning environments.

2. Method

2.1 Participants

The participants were 259 undergraduates with an average age of 19.99 year-old (154 male) in Taiwan. They were invited to complete two instruments regarding the preferences of teacher authority under the context of Internet-based learning and their attitudes toward the Internet.

2.2 *Assessing the university students' preferences of teacher authority toward Internet-based learning environments*

In the present study, a 30-item presented with a 5-point Likert scale Revised Teacher Authority Survey (Revised-TAS) (Lin et al., 2012) was adopted to explore the participants' preferences of teacher authority toward Internet-based learning environments. According to Lin et al. (2012), the Revised-TAS consisted of two aspects, including the learner-centered aspect and the teacher-centered. For each aspect, it contains three dimensions regarding the process, content, and intellectual dimension of teacher authority, respectively. As a result, learner-centered aspects consists of three dimensions with respect to the learner-centered pedagogy, namely Autonomy (AU), Participative Management (PM), and Equity (EQ). In contrast, the teacher-centered aspect includes Dependence (DE), Teacher Control (TC), and Sole Voice (SV). It is noted that, either in the learner or teacher-centered aspects, the process (i.e., AU, DE), content (i.e., PM, TC), and intellectual (EQ, SV) dimensions of teacher authority were embraced. A detailed definition and description of the six scales is presented below:

- Autonomy scale (5 items): measuring preferences of the extent to which students have opportunities to manage and control their learning process to acquire knowledge and concept.
- Participative Management scale (5 items): measuring preferences of the extent to which students have opportunities to design and organize their learning activities, and participate in determining what assessment criteria are.
- Equity scale (5 items): evaluating preferences of the extent to which students have opportunities to make judgment on what counts as knowledge and what knowledge is important.
- Dependence scale (5 items): assessing preferences of the extent to which students perceive the teacher's assistance and support and the teacher's arrangement of their learning content.
- Teacher Control scale (5 items): measuring preferences of the extent to which students perceive the teacher's control of the learning activities and assessment criteria.
- Sole Voice scale (5 items): evaluating preferences of the extent to which students perceive the teacher's judgment of what information or knowledge is important for students to know and how the students should know and learn it.

2.3 *Evaluating the university students' Internet attitudes*

In order to evaluate the participants' Internet attitudes, an instrument was implemented in the present study. That is, the participants' attitudes toward the Internet were assessed by a 20-item Internet Attitude Survey (IAS) (Tsai et al., 2001) with four scales including Perceived Usefulness scale, Affection scale, Perceived Control scale, and Behavior scale. The items were presented in a five-point

Likert scale, ranging from “strongly disagree” to “strongly agree.” A detailed description of the four scales is presented below:

- Perceived Usefulness (5 items): measuring the participants’ perceptions about the positive impacts of the Internet on individuals and society.
- Affection (5 items): assessing the participants’ feeling and anxiety when using the Internet.
- Perceived control (5 items): measuring the participants’ confidence about the independent control of the usage of the Internet.
- Behavior (5 items): assessing the participants’ actual practice and frequency of using the Internet.

2.4 Data analysis and procedure

The purpose of this study was to initially explore the relationships between the university students’ preferences of teacher authority in Internet-based learning environments and their Internet attitudes. First, in order to establish the validities and reliabilities of two adopted instruments, both exploratory and confirmatory factor analyses were performed. The purpose of exploratory factor analysis (EFA) was conducted to reduce the items. In an EFA, only those items with a factor loading of at least 0.40 within their own factor should be retained (Stevenson, 1996). The reliability (Cronbach’s alpha) coefficients were then calculated after the EFA result. Thus, the validity and reliability of the instrument were evaluated accordingly. In addition, confirmatory factor analysis (CFA) was conducted to ensure the construct validity of the two instruments and clarify their ensuing structures.

To initially explore the relationships between the participants’ preferences of teacher authority in the Internet-based learning environments and their attitudes toward the Internet, the Pearson correlation coefficients were performed based on the students’ responses on the two instruments (i.e., Revised-TAS and IAS). The results of the Pearson correlation analysis were then used to build the hypothesized paths. In turn, to explore the structural relationships between the two constructs, path analysis was conducted. The path coefficients were estimated through Structural Equation Modeling (SEM) analysis to acquire the predictive relationships among latent constructs (Kelloway, 1998).

3. Results and Discussion

3.1 Validation of the Revised Teacher Authority Survey

To validate the Revised-TAS, EFA with varimax rotation was performed to initially clarify the structure of the instrument. As a result, a total of 24 items were retained in the Revised-TAS and all items weighted greater than 0.4 on the proposed six factors. The total variance explained for the Revised-TAS instrument was 63.01%. The Cronbach’s alpha reliabilities are 0.70 (AU), 0.80 (PM), 0.66 (EQ), 0.80 (DE), 0.83 (TC), and 0.88 (SV), respectively, and the overall alpha value is 0.87, indicating that the proposed factors had high internal consistency and reliability in assessing the students’ preferences of teacher authority under the context of Internet-based learning environment.

The CFA further served as the purpose of confirming the structure of the Revised-TAS based on the EFA results. Accordingly, all of the factor loadings and the significance of the t-values of the 24 items on the six factors specify the relations of the items to their posited underlying factors. The values of composite reliability are satisfactory, indicating the measured items all consistently represent the proposed six latent constructs. Moreover, the ratio of chi-square per degree of freedom = 1.44, RMSEA = 0.041, GFI = 0.90, NFI = 0.93, NNFI = 0.97, CFI = 0.98. In sum, these results reflect an acceptable model fit which supports our hypothesized CFA model and indicate a reasonably good fit and also confirmed the convergent and construct validity of the Revised-TAS.

3.2 Validation of the Internet Attitude Survey

To validate the IAS, EFA with varimax rotation was performed. Consequently, a total of 16 items were retained and all items weighted greater than 0.4 on the proposed four scales. The total variance explained was 66.00%. The Cronbach’s alpha reliabilities are 0.83 (Perceived Usefulness), 0.86 (Affection), 0.67 (Control), and 0.82 (Behavior), respectively, and the overall alpha value is 0.67,

indicating that the proposed factors had sufficient internal consistency and reliability in assessing the students' Internet attitudes.

The CFA further served as the purpose of confirming the structure of the IAS. Thus, all of the factor loadings and the significance of the t-values of the 16 items on the four factors specify the relations of the items to their posited underlying factors. The values of composite reliability are satisfactory, indicating the measured items all consistently represent the proposed four latent constructs. Moreover, the ratio of chi-square per degree of freedom = 2.61, RMSEA = 0.08, GFI = 0.89, NFI = 0.92, NNFI = 0.94, CFI = 0.95. In sum, these results reflect an acceptable model fit which supports our hypothesized CFA model and indicate a reasonably good fit and also confirmed the convergent and construct validity of the IAS.

3.3 Correlations between Internet attitudes and preferences of teacher authority in the Internet-based learning environments

The results of Pearson correlation analysis indicated that, first, the "Perceived Usefulness" scale of IAS is positively correlated with the "Autonomy," "Equity," "Dependence," and "Teacher Control" scales of Revised-TAS ($r = 0.15\sim 0.32$). Second, the relations between "Behavior" scale of IAS and "Autonomy," "Equity," and "Teacher Control" scales of Revised-TAS are also positively related ($r = 0.19\sim 0.23$). In addition, the relation between "Control" scale of IAS and "Autonomy" scale of Revised-TAS reveals a significant positive relation ($r = 0.16$).

3.4 Path analysis of Internet attitudes and preferences of teacher authority in the Internet-based learning environments

A path model was proposed to further explore the structural relationships between Taiwanese university students' preferences of teacher authority in the Internet-based learning environments and their Internet attitudes. The results showed that the model could approximately explain the collected data. The fit indices were indicative of fair model-to-data fit (e.g., Chi-square per degrees of freedom = 3.53, NFI = 0.80, NNFI = 0.85, CFI = 0.85, GFI = 0.89).

In the model, the Revised-TAS scale "Autonomy" has significantly positive contributions on the IAS scales "Perceived Usefulness," "Control," and "Behavior" ($t = 2.22\sim 3.37$). The Revised-TAS scale "Teacher Control" can only positively contribute to the IAS scale "Behavior" ($t = 2.22$). These path analysis results indicate that, if the students prefer learner-centered *process* authority (i.e., Autonomy), they tend to possess positive Internet attitudes. That is, they may view the Internet more useful, possess higher confidence when using the Internet, and use the Internet more frequently. On the contrary, if the students show their preferences for a teacher-centered *content* authority (i.e., Teacher Control), they are prone to use the Internet more often.

References

- Kelloway, E. K. (1998). *Using LISREL for structural equation modeling: A researcher's guide*. Newbury Park, CA: Sage.
- Lee, M.-H., Chang, C.-Y., & Tsai, C.-C. (2009). Exploring Taiwanese high school students' perceptions of and preferences for teacher authority in the earth science classroom with relation to their attitudes and achievement. *International Journal of Science Education*, 31, 1811-1830.
- Lin, T.-J., Lee, M.-H., Cheng, Y.-W., & Lin, H.-M. (2012). Exploring Taiwanese undergraduates' perceptions of teacher authority toward Internet-based learning environments. Paper presented at the 2012 International Conference on Computers in Education, Singapore.
- Peng, H., Tsai, C.-C., & Wu, Y.-T. (2006). University students' self-efficacy and their attitudes toward the Internet: The role of students' perceptions of the Internet. *Educational Studies*, 32, 73-86.
- Stevenson, J. (1996). *Applied multivariate statistics for the social science* (3rd ed.). Mahwah, NJ: Lawrence Erlbaum.
- Tsai, C.-C., Lin, S.S.J., & Tsai, M.-J. (2001). Developing an Internet attitude scale for high school students. *Computers & Education*, 37, 41-51.
- Yang, F.-Y. & Tsai, C.-C. (2008). Investigating university student preferences and beliefs about learning in the web-based context. *Computers & Education*, 50, 1284-1303.

Promoting Second Language Writers' Error Corrections with Corpus: A Case Study

Hui-Hsien FENG^{a*} & Ying-Hsueh CHENG^b

^aEnglish, Iowa State University, USA

^bGraduate Institute of Digital Learning and Education, Taiwan University of Science and Technology, Taiwan

[*yhc@mail.ntust.edu.tw](mailto:yhc@mail.ntust.edu.tw)

Abstract

How corpora can be used to facilitate second language writing has been of great interest. Previous studies have revealed benefits of this application in non-native English students' writing development. However, how corpora can be used for self error-corrections in essay writing, especially the pattern of corpus consultation, has been little studied. This paper examines the effects of corpus concordancing on error-corrections and student attitudes toward such corpus use in essay writing. Three ESL graduate students enrolled in a US Midwestern university were invited to write three essays that were randomly selected from the TOEFL-iBT essay-question database. The purpose of the essay tasks was three-fold: Essay 1: to assess students' writing competence before training; Essay 2: to examine students' application of *corpus concordancing* to revise Essay 1; Essay 3: to evaluate students' use of corpus consultation to write another essay after training. The results showed that in Essay 2, the students corrected the most "word choices" and in Essay 3, they tended to prevent poor word choices. In addition, the students perceived the corpus training as beneficial to self error-corrections in essays. This paper concludes with pedagogical and research implications.

Keywords: Second language writing, corpus linguistics, writing instruction

1. Introduction

Writing is one of the most important skills in academic contexts. However, nonnative English speakers (NNES) often have difficulty producing texts that are syntactically, lexically, and pragmatically appropriate (Yoon & Hirvela, 2004; Yoon, 2008; Bloch, 2009). Their difficulty is often related to their lack of knowledge in collocations, first language interference, and confusion of word choices (Fan, 2009). They tend to make errors that are different from those made by native English speakers (NES) (Gilquin, Granger, & Paquot, 2007). Facing this situation, instructors and researchers have called for the application of corpus search results in academic writing. The corpus database allows learners to type in a keyword and see a long list of authentic uses of the word with different collocations. These uses occur in the form of portions of sentences, with the keyword positioned in the middle of them. For example, if we type in the word *research*, we will see a series of the keyword in use in the following:

have a very relevant social impact. **Research** in assistive technology for VI people has resulted in some very useful products. In this article, we review current **research** work in this field, analyze the causes of past failed experiences, and propose promising **research** directions marrying computer vision and assistive technology. **Research** must be involved at all stages of design, **research**, and development. Particular attention must be paid to the development of technology that has been reported. However, the bulk of **research** on wayfinding has focused on piloting, with very few products based on technology developed at The Smith-Kettlewell Eye **Research** Institute. Already deployed in several countries, it has a wide range and lack of directionality. A promising **research** direction is the use of computer vision to detect natural color images collected offline. Note that some of this **research** work (for example, Hile et al. 11) was aimed to support systems intended for normally sighted users. **Research** is under way to expand the reach of OCR beyond code location on a package). Some **research** in this area 17,31 has specifically investigated the usability of these systems. Over the past decade, increasing **research** efforts within the computer vision community have focused

Figure 1. Concordance Output Of The Word “Research” From
Corpus of Contemporary American English (COCA).

The output listed above is called “concordance output” which can be used by students to study how a keyword functions in context with other related words (Yoon & Hirvela, 2004). The purpose of a concordance program is to produce the word list. Corpus concordancing as lexico-grammatical consultation has been introduced into second language (L2) writing classrooms. Many studies have reported that NNES students benefit from the use of corpus concordancing in collocations and overall writing performance (e.g., Gilmore, 2008; O’Sullivan & Chambers, 2006; Todd, 2001; Yoon & Hirvela, 2004). However, few studies have investigated the connection between the use of corpus concordancing and students’ self error-corrections (Gaskell & Cobb, 2004; Gilmore, 2008; O’Sullivan & Chambers, 2006). In this paper, we examined the effects of corpus concordancing on students’ self error-corrections in essay writing and their attitudes toward the use of this corpus.

2. Literature Review

Corpus Research in L2 Writing

The term “corpus” first occurred in 1969. It became popular since the 1980s for its application for different purposes (O’Sullivan & Chambers, 2006). A corpus can be defined as “a collection of sampled texts, written or spoken, in machine-readable form which may be annotated with various forms of linguistic information” (McEnery, Xiao, & Tono, 2006, p. 4). It is a searchable language database for various functions. For example, learner corpora were developed to analyze L2 students’ errors to show how adequate their L2 perceptions are (Belz & Vyatkina, 2008; Gilquin et al., 2007).

Corpora have been introduced into L2 writing classrooms to provide students with authentic materials and concordances for inductive learning (e.g., O’Sullivan & Chambers, 2006; Yoon & Hirvela, 2004). By consulting a corpus, English-as-a-Foreign-Language (EFL) students gain help in improving the naturalness of their writing (Gilmore, 2008). Numerous studies have been conducted to explore L2 learners’ attitudes/experiences of using corpus and L2 learning performance/outcomes (Cheng, Warren & Xun-feng, 2003; O’Sullivan & Chambers, 2006; Yoon, 2008; Yoon & Hirvela, 2004). Moreover, EFL student-teachers are encouraged to attend corpus-related training sessions to better understand how to incorporate this instructional and research tool in their classrooms (Breyer, 2009). Corpora offer an easy-to-search authentic language database for learners to consult and learn from.

When using the corpus, learners first focus on the word they are interested in, and then they look for patterns to illustrate the word’s usage. One of the purpose of this study is to understand how learners apply patterns and rules they derived from the corpus concordancing program in order to modify errors by themselves, which is also called self error-correction.

Self Error-Correction

The question regarding whether errors should be corrected has been long debated. Some argued that errors should not be corrected (Truscott, 1996, 1999) while others suggested that error-correction is necessary (Ferris, 1999, 2004). Although the results were inconclusive, it seems that students correct their errors better if they receive some kind of error identification.

Few studies have reported on the connection between self error-correction and corpus concordancing. Here we review a handful of studies related to the current study.

Gaskell and Cobb (2004) presented a case where the teacher hyperlinked concordance lines to students' errors as a form of feedback in their first four essays so that students could consult the corpus by themselves. After that, students were asked to write other essays. However, after the teacher stopped providing hyperlinks to essays, students did not use the corpus as often as they had in the first four essays. As for the occurrences of types of errors, the study found that by comparing pre-test and post-test sample essays, the number of errors with word choice, capitals/punctuation, and pronouns decreased, but the number of errors with articles, noun pluralization, and subject-verb agreement increased.

Similar to the previous study, Gilmore (2008) studied how corpus concordancing could improve English writing for 45 second-year intermediate-level Japanese learners who enrolled in an English academic writing course. Sentence-level, lexical, and grammatical errors were underlined by the instructor. To make their sentences more native-like, the students made changes with the use of a corpus.

O'Sullivan and Chambers (2006) investigated the effects of corpus consultation for French writing by 14 English speakers who were undergraduate and master's students in the University of Limerick and majoring in Applied Languages and Applied Languages with Computing. The teachers marked the locations of errors in the papers and then asked students to revise by consulting a researcher-compiled French corpus. The results showed that learners tended to correct grammatical errors.

The above studies indicate that teachers gave students implicit corrections and encouraged them to consult a corpus to learn how to deal with the errors. In review of related literature, we found that corpus concordancing program could help L2 students in their writing processes. However, how such program can be applied for self error-corrections in essay writing, particularly the patterns of corpus consultation, has not been studied.

3. Research Questions

Two questions guided this study:

1. What are the effects of *corpus concordancing* on students' self error-corrections in essays?
2. What are the student attitudes toward the use of *corpus concordancing* in their self error-corrections and overall writing practice?

4. Methods

This study adopted a mixed-method design in order to answer the research questions. Both qualitative and quantitative data were collected concurrently.

Participants

This study took place in an ESL academic writing tutorial class in a US Midwestern university. Since this was intended as a pilot study, only three students were recruited for the study. They were one male and two female graduate students. All of them were from China. Their average age was 22. Their English proficiency level was at least in the intermediate-level based on their TOEFL scores upon their admission into the university. They majored in these academic programs: Physics, Chemistry, and Informational Computer. The reason that we recruited these participants was also because none of them had previous experience of using the corpus concordancing program.

Materials

Materials used for data collection included the following:

- Synonymous lexical items (Tsui, 2004, p. 44) for students to complete corpus consultation activities.

- Two writing prompts from the TOFEL-iBT essay question database (for pre- and post-training sessions).
- Corpora used for student consultation: Corpus of Contemporary American English (COCA)² and Lexical Tutor: Concordance (LTC)³.
- Survey questions using a four-point scale and open-ended items for pre- and post-testing.
- Semi-structured interviews conducted in the middle of and at the end of all the sessions.

Procedure

Materials used in the study were summarized in Table 1:

Table 1: Stages and tasks

Stages	Tasks
1	Pretest: Essay 1
	Pre-Survey
2	Training
	Practice: Essay with corpus (not collected)
	Observations
	Field notes
	Audio recordings
3	Revision of Essay 1 (Becomes Essay 2)
	Four corrected errors
4	Essay 3
	Four corrected errors
	Screen-recording
5	Post-survey
	Group discussion
	Individual interviews

Data analysis

All research questions were answered by both qualitative and quantitative data. In terms of the first research question (What are the effects of *corpus concordancing* on students' self error-corrections in essays?), screen-recordings and interviews with students were triangulated in order to investigate how they accomplished self error-correction. Frequency analysis was applied to compare the differences between errors in three essays. Observation notes and student interviews were also used for triangulation.

As for the second researchquestion, (What are the student attitudes toward the use of corpus concordancing in their self error corrections and overall writing practice?), several techniques were applied. These techniques included survey responses, field notes from observations, group discussions, and individual student interviews.

5. Results and Discussion

The Effects of Corpus Concordancing on Error Corrections

Overall, the number of errors decreased due to the use of corpus concordancing and dictionaries. In Essay 1 (average word count: 310), there were 70 errors (23%). Students most frequently committed word choice (n=17, 24%) and conjunction (n=10, 14%) errors. In Essay 2 (revised Essay 1), the total corrected errors were 59 (84%). The students corrected most of the errors of word choice (n=14, 20%) and conjunction (n=9, 13%). There were 11 errors that students did not correct, either because of the

²COCA: <http://corpus.byu.edu/coca/>

³LTC: http://www.lextutor.ca/concordancers/concord_e.html

lack of time, understanding of errors, or ability to perform an effective search. In Essay 3 (average word count: 372), students committed 55 (18%) errors. The errors students committed most frequently were word form ($n=20$, 36%) and article ($n=8$, 15%) errors.

Comparing Essays 1 and Essay 3, the number of errors decreased but the word counts increased. Notably, the number of errors of “word choice” decreases (17%, $p = 0.07$). This is similar to Gaskell and Cobb’s (2004) result. They also found that the errors of word choice were significantly decreased comparing pre- and post- sample essay from their participants. It could suggest that with the facilitation of corpus concordancing and dictionaries, students gain more support with word choice, so that they do not make as many errors as in Essay 1. On the other hand, “word form” errors increased 25% from Essay 1 to Essay 3 ($p = 0.06$). This might suggest that, when students received support, they spent more time searching for word choice, but spent less time checking their usage of the word form, which had to be identified by them.

Student Attitudes toward Corpus Concordancing and L2 Writing

From the post-test survey, the students thought that corpus concordancing would help their writing in the future (92%). They believe that “Having teachers to identify your mistakes, and you correct them by yourselves” is the most effective way to improve their writing (100%). From the interviews, they reiterate the importance of having teachers to identify their errors would be the most beneficial for their future writing. Nevertheless, when asked the most beneficial way to improve their writing when there is no teacher, they say, “then, corpora will be needed in that case.” They also realized when the best time is to use corpus concordancing. They used it as a supplement to rather than a replacement for dictionaries, especially when they needed to look for the usage or collocations of words and to distinguish the differences between synonyms.

6. Conclusion and Implication

The purpose of this study is to examine how corpus concordancing affects self error-correction process in essays and learners’ attitudes toward corpus concordancing in facilitating their error-correction processes. The results suggest that writing with the facilitation of corpus consultation would better improve students’ writing. Students held a positive attitude toward using corpus concordancing in their future writing. They regarded corpus as a supplement rather than a replacement for dictionaries.

A few pedagogical implications are offered. By implementing corpus concordancing, it is hoped that teachers’ workload of providing students writing feedback could be decreased. Moreover, it is hoped that students would become more independent and responsible for their error corrections because corpus concordancing would facilitate at least certain types of errors.

For future studies, this paper has some research implications to offer. First, the findings based on only three participants are too limited to be generalized to other learner groups or classroom contexts. It is suggested that future studies can recruit more participants to better examine the effects of corpus use in academic writing and also student attitudes toward corpus use. Moreover, due to time constraints, data collection was completed in merely nine hours with three essays. To what extent corpus consultation could help students with their error corrections during a longer period of time is unknown. It would be better if the time frame could be extended for data collection and for more training sessions.

Acknowledgements

We would like to thank the three participants for their time and help in this study.

References

- Belz, J. A., & Vyatkina, N. (2008). The pedagogical mediation of a developmental learner corpus for classroom-based language instruction. *Language Learning and Technology*, 12(3), 33-52.
- Bloch, J. (2009). The design of an online concordancing program for teaching about reporting verbs. *Language Learning & Technology*, 13(1), 59-78.
- Breyer, Y. (2009). Learning and teaching with corpora: Reflections by student teachers. *Computer Assisted Language Learning*, 22(2), 153-172.
- Cheng, W., Warren, M., & Xun-feng, X. (2003). The language learner as language researcher: Putting corpus linguistics on the timetable. *System*, 31(2), 173-186.
- Fan, M. (2009). An exploratory study of collocational use by ESL students – A task based approach. *System*, 37(1), 110-123.
- Ferris, D. (1999). The case for grammar correction in L2 writing classes: A response to Truscott. *Journal of Second Language Writing*, 8(1), 1-10.
- Ferris, D. (2004). The “grammar correction” debate in L2 writing: Where are we, and where do we go from here? (and what do we do in the meantime...?). *Journal of Second Language Writing*, 13(1), 49-62.
- Gaskell, D., & Cobb, T. (2004). Can learners use concordance feedback for writing errors? *System*, 32(3) 301-319.
- Gilmore, A. (2008). Using online corpora to develop students' writing skills. *ELT Journal*, 63(4), 363-372.
- Gilquin, G., Granger, S., & Paquot, M. (2007). Learner corpora: The missing link in EAP pedagogy. *Journal of English for Academic Purposes*, 6(4), 319-335.
- McEnery, T., Xiao, R., & Tono, Y. (2006). *Corpus-based language studies: An advanced resource book*. London: Routledge.
- O'Sullivan, I., & Chambers, A. (2006). Learners' writing skills in French: Corpus consultation and learner evaluation. *Journal of Second Language Writing*, 15(1), 49-68.
- Todd, R. (2001). Induction from self-selected concordances and self-correction. *System*, 29(1), 91-102.
- Truscott, J. (1996). The case against grammar correction in L2 writing classes. *Language Learning*, 46(2), 327-369.
- Truscott, J. (1999). The case for ‘The case against grammar correction in L2 writing classes’: A response to Ferris. *Journal of Second Language Writing*, 8(2) 111-22.
- Tsui, A. B. M. (2004). What teachers have always wanted to know – and how corpora can help. In J. M. H. Sinclair (Ed.), *How to use corpora in language teaching* (pp. 39-65). Philadelphia: John Benjamins.
- Yoon, H. (2008). More than a linguistic reference: The influence of corpus technology on L2 academic writing. *Language Learning & Technology*, 12(2), 31-48.
- Yoon, H., & Hirvela, A. (2004). ESL student attitudes toward corpus use in L2 writing. *Journal of Second Language Writing*, 13(4), 257-283.

Using Internet as Research Tool: An Example of Meta-Analysis Study

Shih-Hsuan WEI

Graduate Institute of Digital Learning and Education, University of Taiwan of Science and Technology, Taiwan

**scottiemath@gmail.com*

Abstract: In this paper, we describe how internet can be used as a research tool through providing a study conducted by meta-analysis. Student academic success has always been a priority in education and mathematics education has been a major focus over last few decades. The quality of teachers is one of the most significant factors in shaping the growth and learning of students. The purpose of this study was to review the existing empirical studies accumulated to draw conclusions about various aspects of teacher qualifications that were linked with student mathematics achievement. A meta-analysis was used to provide a descriptive analysis of the existing empirical studies.

Keywords: Internet, Meta-analysis, Teacher Characteristics, Student Achievement, Mathematics

1. Introduction

Researchers are typically interested in finding general answers to questions. Nowadays, we live in an age of technology. Researchers can access journals, magazines, newspapers, and encyclopedias from Internet. Technologies support researchers' exploration and collaboration skills included Internet search engines, online tools for evaluating Web-based information. The Internet has become the universal source of information and also simplified the research process. Consequently, use of the Internet search engines can promote researchers' research skills and techniques and enable them to locate information relevant to any given topic efficiently.

2. Meta-analysis?

Why do Meta-Analysis

Science is cumulative, and scientists must cumulative scientifically. Often times, researchers find themselves going through a dense amount of papers on a certain topic only to find results that do not really seem to point towards a coherent or homogenous conclusion. Single study is often not reliable enough to detect significant differences between two treatments. Multiple studies are needed to reassure researchers the results were not just a coincidence. Therefore, researchers need to understand how an intervention performs in different contexts. For example,

Table 1: An example on the correlation between self-efficacy and job performance

Study	Correlation	Sample Size	<i>p</i> value
1	.25	120	.26
2	-.12	250	.55
3	.33	25	.06
4	.17	95	.26

If the researcher conducted Studies 1 and 3, he/she might claim that there was a positive relationship between self-efficacy and job performance. On the other hand, if the researcher conducted Studies 1 and 2, he/she might conclude that there was no linear relationship. Therefore, the results would look contradicting. In order to avoid errors of “vote counting;” it takes account of the magnitude of the effect estimate, and reveal new patterns and relationships. A statistical method, “Meta-analysis,” can come as a key element to handle a large volume of information in an organized way.

Put simply, meta-analysis is a quantitative analysis that summarizes, integrates and interprets the results of selected sets of the results of empirical research studies in the various disciplines into a coherent product (Hedges & Vevea, 1998; Hunter & Schmidt, 2004; Lipsey & Wilson, 2001). In sum, meta-analysis synthesizes available quantitative information in previous studies and provides precise and systematic results to support a specific hypothetical statement.

Traditionally, performing a meta-analysis required the use of a range of applications - An internet browser for search, a filing system to sort papers for later reference, a word processor or spreadsheet application to make comments on these papers, and a referencing application to make in-text citations and reference lists. In this study, the topic of “The Effect of Teacher Characteristics on Students Mathematics Achievement” will be used as an example to demonstrate how such meta-analysis was conducted.

Research Question

Politicians and school districts evaluate the qualification of incoming teachers based on readily available credentials highlighted by federal government such as certification, academic degrees, test scores, and the amount of completed coursework. In the current climate of educational accountability and the decline of educational monetary resources in schools, how to measure and evaluate teacher qualification and identify the precise hiring methods district can use to make hiring decisions becomes an important issue. Having a clear understanding of the findings regarding teacher quality can further enhance the effort in seeking qualified teachers and highly impact the course of future teacher policy. To this end, a meta-analysis with random-effects model was used to provide a descriptive analysis of the existing empirical studies in this area. Specifically, this study was designed to seek answers to the following research questions:

1. What is the average effect size representing each teacher characteristic on student achievement? Is the average effect size significantly different from zero?
2. Which factors are related to the variability in effect size?
3. How does the result of current study compare to previous meta-analyses?

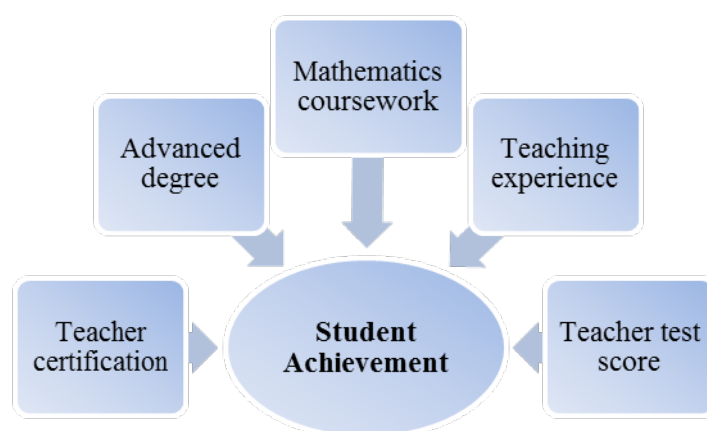


Figure 1. Teacher Characteristics and Student Achievement

Method

2.1.1 Search Strategy and Study Selection Criteria

The majority of the reports were identified through searches of electronic databases, including Educational Resources Information Center (ERIC), ERIC EBSCO, Psychological Abstracts (PSY), PsycINFO, PsychLit, EconLit, Social Sciences Citation Index, Dissertation Abstracts International (DAI), and ProQuest dissertations and theses. Several journal websites were also used. These journals were American Educational Research Journal, Educational Studies in Mathematics, Journal for Research in Mathematics Education, Journal of Educational Psychology, Journal of Educational Research, Review of Educational Research, and School Science and Mathematics.

Furthermore, general web searches using standard search engines, such as Google and Google Scholar, were conducted. Keywords relevant to this dissertation used in searching included “teacher characteristics,” “teacher knowledge,” “teacher preparation,” “mathematics education” and “student performance”. Subsequent searches were expanded by using various combinations of alternatives for achievement, such as “performance,” “success,” and “outcomes,” and by combining them with individual mathematics disciplines, such as “number and operation,” “algebra,” “geometry,” “trigonometry,” and “pre-calculus.” Other terms, such as “mathematics teaching” and “professional development” were also used in search strings.

Using this search procedure, 282 studies met the initial screening criteria. Due to the vast amount of article findings provided from the computerized search, inclusion criteria were needed. Studies for this meta-analysis were selected based on the following criteria:

1. The study was published no earlier than 1960.
2. The study was published in a journal article, conference paper, and dissertation or working paper.
3. The study was only included once.
4. The study was conducted with public school K-12 mathematics teachers and students.
5. The study reported student mathematics achievement using either test results or students grades.
6. The study reported on a measure of teacher knowledge in mathematics.
7. The study used student achievement in mathematics as dependent variable.
8. They study was included only if they used a correlational design.
9. The study reported enough information to compute an index of effect size such as a correlation, regression coefficient, or other test of association linking the teacher knowledge measure to the achievement outcome.
10. The study was conducted in the United States.

2.1.2 Coding Procedure

When a more in-depth examination was performed, several studies were eliminated because they did not meet all specified inclusion criteria and/or because they were duplicates. The final set of 40 studies included 25 journal articles, 2 conference papers, 7 working papers, and 6 dissertations.

2.1.3 Computation of Effect Size

A weighted mean effect size, Pearson’s r , was computed by Comprehensive Meta-analysis program. A confidence interval was set at 95 percent in order to estimate the precision of each mean effect size. SPSS was used to illustrate the confidence interval of individual and overall effect sizes. If the variation in effect size was not caused by sampling error, a follow-up moderator variable analysis was conducted with a between-group heterogeneity test. Additionally, Pearson’s r correlation is one of the most widely used effect sizes. Cohen (1988, 1992) provided the following guidelines for the social sciences: small effect size, $r = .10$; medium effect size, $r = .30$; and large effect size, $r = .50$.

Table 2: The correlation between teacher characteristic and student Mathematics achievement

Variable	R
Coursework	.17***
Certificate	.03***
Test Score	.38***
Advanced Degree	-.05***

Experience	.24***

*** $p < .001$

The study not only calculated the effect size of each teacher characteristic and student achievement, the heterogeneity of variance between-group groups test was also conducted to examine the statistical differences in the overall mean effect sizes among the subgroups. Binomial Effect Size Display, Fail-Safe N, Forest Plot, and comparison with prior meta-analyses were also included in the study to ensure the necessity of meta-analysis.

2.1.4 Criticism of Meta-Analysis

Although meta-analysis is very powerful, it still has its limitation. One of the weaknesses is that it requires a good deal of effort, and it is much more labor-intensive and time-consuming than a traditional literature review. Another and the most common criticism of meta-analysis is the apples and oranges issue. Although it may seem ideal to combine results of studies, this procedure may not always be appropriate. In dealing with this issue, it is necessary to ascertain that the studies involved examine the same research question. Publication bias also arises from the tendency of journals to reject negative studies. This bias, often called the file-drawer effect because the unpublished results are imagined to be tucked away in researchers' file cabinets, is a potentially severe impediment to combining the statistical results of studies collected from the literature.

3. Importance of Internet Use

Before the Internet, conducting research involved a set of encyclopedias and a trip to the library. Nevertheless, we now live in an age where information is readily accessible from our computers. The use of the Internet has increased dramatically in recent decades and, consequently, finding information about the topic as desire through internet has attracted more and more researchers' attention. Within these technologies, many ethical and methodological issues also arise in the research process. Therefore, researchers should be aware of some of the morally important concerns need to be taken into ethical evaluation and consideration with the potential unintended consequences of the study

References

- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Hillsdale, NJ: Erlbaum.
- Cohen, J. (1992). A power primer. *Psychological Bulletin*, 112, 155-159.
- Hedges, L.V. & Vevea, J.L. (1998). Fixed and random-effects models in meta-analysis. *Psychological Methods*, 3, 486-504.
- Hunter, J. E., & Schmidt, F. L. (2004). *Methods of meta-analysis: Correcting error and bias in research findings*. Newbury Park, CA: Sage.
- Lipsey, M. W., & Wilson, D. B. (2001). *Practical meta-analysis*. Thousand Oaks, CA: Sage.

Development questionnaire about High school students learning science and technology in the 21st century

Chih-Hui LIN* & Jyh-Chong LIANG

Graduate Institute of Applied Science and Technology

National Taiwan University of Science and Technology, Taiwan

[*M10122303@mail.ntust.edu.tw](mailto:M10122303@mail.ntust.edu.tw)

Abstract:

This study revised three surveys. The development of questionnaires was focused on three major themes: 21st century learning ability, Teacher Authority Survey (TAS), and Self-efficacy. Firstly, 21st century learning ability is the relationships among students' perceptions for collaborative learning, critical thinking, self-directed learning, creative thinking, meaningful use of Information and communication Technology (ICT), problem solving, knowledge creation efficacy, design disposition, teacher authority, and learning achievements. And, secondly, name Learning in schools and the preferred version of TAS questionnaire, and utilize both of them to elicit high school students' conceptions of learning and preferences of teacher authority in classroom. The study aims to develop a questionnaire to explore High school students' learning science and technology in the 21st century.

Keywords: 21st century learning ability, TAS, Self-efficacy, ICT

1. Introduction

The implications of the implementation of 21st century competences in national curriculum policies have been discussed and recommendations are provided in many previous studies. Several (international) organizations and scholars have attempted to promote the integration of 21st century competences in national curriculum policies by providing descriptions of the competences that are regarded as important issues for the knowledge society. These descriptions are usually accompanied by specifications of the types of teaching, learning, and assessment approaches associated with the implementation of these competences in school curricula (Joke Voogt & Natalie Pareja Roblin, 2012). Globalization has changed the way in which most people live, work and study in the 21st century. Students and teacher educators, such as other professionals, have to embrace these changes to be effective in their jobs and the ongoing change is the use of Information Communication Technologies (ICT) for lifelong learning.

There is a relationship between learning in school and learning by preferences for teacher authorities among high school students in Taiwan. The relationships between learning context and learners during the learning process have attracted more and more attentions in educational researchers. In Biggs' 3P model of student learning (2001), learning contexts and learners are presages of learning outcomes.

There are two factors that influence of learning process: (1) The factors of learning context, such as Assessment, Climate, Teaching parameters, and Teacher authority; and (2) the factors of learners, such as Attitude, Motive, Conception, and Belief. If we take learners as the kernel of the whole learning process, there exist two perspectives to investigate the relationships between learning context and learners, from the inside out and from the outside in.

Based on Biggs' 3P model of student learning (2001), there are two cognitive and affective flow of learning, which is from outside in (Cognitive dimension, situated views of cognition and perceptions of contexts) and is from inside out (Affective dimension, Conception of learning, and Differentiated instruction).

In the other research by Lee, Chang, and Tsai (2009) found that teacher authorities in the science learning environment may have a potential impact on students' learning outcomes, including

achievement and attitudes. Tsai (2004) suggested that conceptions of learning represent students' beliefs about school knowledge and learning in general. Both factors are important factors to determine student performance. Based on previous studies, researchers want to know the relationship between two independent variables.

2. Method

The development of questionnaires was focused on three major themes: 21st century learning ability, Teacher authorities, and Self-efficacy.

2.1. 21st century learning ability

From the article (A comparative analysis of international frameworks for 21st century competences: Implications for national curriculum policies, Joke Voogt & Natalie Pareja Roblin, 2012) found that there are strong agreements on the need for competences in the areas of communication, collaboration, Information and communication technology (ICT), which was related to competences, and social and/or cultural awareness. Creativity, critical thinking, problem-solving, and the capacity to develop relevant and high quality products are also regarded as important competences in the 21st century by most frameworks.

The 21st century competences needed in the knowledge society can be regarded as the overall rationale and goals for learning. Therefore, eight themes describing 21st century learning ability is developed. Totally, there were 48 items in the questionnaire and it was designed to measure students' perceptions of learning environment.

2.1.1 Collaborative learning

Knowledge converges in collaborative case-based learning. Methods of case-based learning have repeatedly been proposed for implementation in teachers' education. It is because learning with cases and problems is ascribed to high potential for promoting analytical, problem-solving skills, and for overcoming inert knowledge (e.g., Levin, 1999 and Merseth, 1996).

In collaborative learning, as can be seen in Table 1. For example, learners are supposed to develop a similar understanding of which aspects or situational cues of the given case are important. Then, apply appropriate principles to them (see Choi & Lee, 2009). As O'Neill, Scott and Conboy (2011) pointed out that several studies have demonstrated the superiority of collaborative learning over traditional modes of learning. These authors indicate that working in groups is not just a valuable way of learning but also develops the abilities for cooperative work, which are essential in the modern working place.

Table 1: Collaborative learning

Theme 1	Description	
	Learner-centered aspect: Learning in school...	
Collaborative learning	1	In this class, my classmates and I actively work together to complete tasks.
	2	In this class, my classmates and I actively discuss different views we have about things we are learning.
	3	In this class, I get helpful comments about my work from my classmates.
	4	In this class, my classmates and I actively work together to learn new things.
	5	In this class, my classmates and I actively share and explain our understanding.

2.1.2 Critical thinking

Mentioned in Table 2 critical thinking, or capacity to apply rigorous logical processes in judging the merits of evidence, is clearly relevant to scientific inquiry and learning of science. It also has been defined in various ways by others. For example, Lipman defines critical thinking as “skillful, responsible thinking that facilitates good judgment because it relies upon criteria, is self-correcting and is sensitive to context” (Lipman, M. Educ. Leadership 1988). Siegel states that “a critical thinker is one who appreciates and accepts the importance and convicting force of reasons” (Siegel, H. Synthese 1989).

Ennis’s definition may be most widely used; he stated critical thinking as “reasonable reflective thinking that is focused on deciding what to believe or do” (Ennis, R. H1987). It is clear that the process of deciding what to believe or to do depends on the learner’s epistemological commitments—that is, his or her standards of judging knowledge—and the use of reflective thinking depends on his or her metacognitive processing. Hence Kuhn asserted that critical thinking should be viewed as metacognition rather than cognition (Kuhn, D. Educ. Res. 1999).

The critical inquiry starts with a triggering phase involving an issue, a dilemma, or a problem. The participants then engage in a process of social exploration of ideas. (Chin-Chung Tasi, 2010) These interactions allow participants with various perspectives to contribute their ideas in an environment where social status (e.g., academic level) and other social, cultural, and academic contextual factors become less important. And, critical thinking may become more important.

Table 2: Critical thinking

Theme 2	Description	
	Learner-centered aspect: Learning in school...	
Critical thinking	1	In this class, I think about whether or not what I learnt is true.
	2	In this class, I have opportunities of judging the value of new information or evidences presented to me.
	3	In this class, I think about other possible ways of understanding what I am learning.
	4	In this class, I evaluate different opinions to see which one makes more sense.
	5	In this class, I decide what kind of information can be trusted.
	6	In this class, I distinguish what are supported by evidence and what are not.

2.1.3 Self-directed learning

Self-directed learning requires self-assessment of learning needs and performance. Modern learning principles suggest that learning strategies should be self-directed rather than teacher-directed, and should encourage independent decision making as well as make students become aware of their own deficiencies (Knowles 1984; Rolfe & Sanson-Fisher 2002; Sanson-Fisher et al. 2005). The aim of this in Table 3 study was to gain insight into how learners process external information and apply their interpretation of this information to their self-assessment and learning during a structured educational activity.

Table 3: Self-directed learning

Theme 3	Description	
	Learner-centered aspect: Learning in school...	
Self-directed learning	1	In this class, I set goals for my studying.
	2	In this class, I make plans for how I will study.
	3	In this class, I check my progress when I study.
	4	In this class, I think about different ways or methods I can use to improve my study.
	5	In this class, I reflect about the ways I study.
	6	In this class, I adjust the ways I study based on my progression.

2.1.4 Creative thinking

An innovative approach to measuring knowledge convergence was introduced. Table 4 gives an example. In a complex and rapidly changing globalized world, it is critically important that teachers and teacher educators engage in debate, decision making, new knowledge creation, and action for change.

Table 4: Creative thinking

Theme 4	Description	
	Learner-centered aspect: Learning in school...	
Creative thinking	1	In this class, I generate many new ideas.
	2	In this class, I create different solutions for a problem.
	3	In this class, I suggest new ways of doing things.
	4	In this class, I design objects that may be helpful.
	5	In this class, I produce ideas that are likely to be useful.
	6	In this class, I develop innovative ideas.

2.1.5 Meaningful use of ICT

Information and communication Technology (ICT) is in the core of each of the frameworks. Not only the development is regarded as an argument for the need of new competences by all frameworks, but it is also associated to a whole new set of competences about how to effectively use, manage, evaluate, and produce information from different types of media. (Joke Voogt & Natalie Pareja Roblin, 2012)

Interest in social networking practices and their educational implications are growing as a new field of digital media. Also, learning brings together learning scientists, educational technologists, instructional designers, literacy theorists, and media scholars to explore, debate, and envision systemic change for education in the digital age (Greenhow & Burton, 2011). As Cho, Gay, Davidson and Ingraffea (2007) indicated, a growing body of research has demonstrated that a social network is a central element in collaborative learning environments.

Table 5 presents an overview of the various frameworks analyzed. Computer-supported learning environments enable learners to work with video cases in new and innovative ways, such as annotating case videos (Fu, Schaefer, Marchionini, & Mu, 2006). Recent studies that compared annotation-based environments with discussion boards have provided some evidence. It is that the ability to easily link annotations to specific passages of a primary document can positively influence the quality of subsequent discussion through an increase of task-directedness and deeper elaboration of content (e.g., Wolfe, 2008)

Table 5: Meaningful use of ICT

Theme 5	Description	
	Learner-centered aspect: Learning in school...	
Meaningful use of ICT	1	In this class, I construct ICT-based materials (e.g. PowerPoint slides, word documents, mindmaps) to represent my understanding.
	2	In this class, my classmates and I actively communicate online (e.g. LMS, Discussion Forum, Facebook, Wiki etc.) to learn new things together.
	3	In this class, I find out useful information on the Internet to help my learning.
	4	In this class, I use the computer to organize and save the information for my learning.
	5	In this class, I use the computer to record my ideas for my learning progress.
	6	In this class, I use the computer to remix/re-organize information from other resources.

2.1.6 Problem solving

The key question tackled in Table 6. This field concerns how to identify and create the most favorable conditions for effective learning and development; thus, prepare learners to cope with challenges, such as deeply understanding concepts, theories and principles; making causal reasoning; solving complex problems; and exercising critical and creative thinking.

Table 6: Problem solving

Theme 6	Description	
	Learner-centered aspect: Learning in school...	
Problem solving	1	In this class, I am challenged by many real-world problems.
	2	In this class, I learn about real-life problems that people have.
	3	In this class, I investigate the reasons that give rise to real-world problems.
	4	In this class, I apply the knowledge I have to solve real-life problems.
	5	In this class, I practice solving real-world problems.
	6	In this class, I think about whether my solutions to real-world problems are good.

2.1.7 Knowledge creation efficacy

The center of this analytical framework is a shift from shared understanding to an individual's independent construction of knowledge in multiple-week discussions. (Chin-Chung Tasi, 2010) In online knowledge building, making judgments with supporting examples or with justifications of new information is viewed as in-depth processing during online discussions (Hara et al. 2000).

The aim of it in Table 7 study was to gain the rich variety of information on the Internet, which may also help students develop the metacognitive skill of information organization; that is, keep track of sources of information and merge them with newly identified information on the Internet.

Table 7: Knowledge creation efficacy

Theme 7	Description	
	Learner-centered aspect: Learning in school...	
Knowledge creation efficacy	1	I am able to connect different ideas to form new ideas.
	2	I am able to build explanations/theories about things related to the issues that I am learning.
	3	I am able to create useful ideas that may help to address problems in our society.
	4	I am able to design things that may be useful.
	5	I am able to create useful knowledge on my own.
	6	I am able to generate new ideas about what I am learning.
	7	I am able to find answers to questions that I want to understand.

2.1.8 Design disposition

As can be seen in Table 8, develop a positive disposition to learn and make use of higher-order thinking skills.

Table 8: Design disposition

Theme 8	Description	
	Learner-centered aspect: Learning in school...	
Design disposition	1	I am comfortable with the presence of uncertainty.
	2	I am open to new ideas about how things can be done.
	3	I am comfortable to explore conflicting ideas.
	4	I am comfortable to deviate from established practices.
	5	I am comfortable with occasional failures from trying out new

		approaches for teaching.
	6	I am constantly seeking to turn constraints into opportunities.

2.2. TAS

This questionnaire was modified from the ESCLEI used in our previous study (Chang et al., 2006; Lee & Chang, 2004), and the description of items on the TAS was revised to encompass teacher authority in particular.

Oyler (1996) stated that teacher authority can be analyzed from both the process dimension and the content dimension. Thus, the items of the TAS were revised from the items of the ESCLEI with the description regarding the course content and the processes in the classroom.

In order to assess students' perceptions of and preferences for teacher authorities in the classroom, researchers adapted from The Teacher Authority Survey (TAS). This questionnaire was modified from The Teacher Authority Survey (TAS) (Lee, Chang, & Tsai, 2009), and the description of items on the TAS was modified to cover teacher authorities in particular situation. The Teacher Authority Survey (TAS) has 20 items and it was designed to measure students' perceptions of learning environment with a focus on learner-centered and teacher-centered components that cover curriculum content, teaching process, and assessment.

2.3. Self efficacy

2.3.1. Definition of Self efficacy

Self-efficacy is individual belief on their self to do certain task (Bandura, 1997). Dale Schunk (2001) states self-efficacy will influence their task preference. For example, individual with low self-efficacy avoid hard task especially challenging task; however, individual with high self-efficacy have great desire to motivate their self to do challenging task. Bandura (1997) explain self-efficacy will be different in every task and self-efficacy will influence task preference, effort, perseverance, endurance, and achievement.

2.3.2. Influencing factor of self-efficacy

Bandura (1997) explained there are three major factors that influence self-efficacy which are:

1. Mastery experiences

Successful experience will increase self-efficacy and failure will reduce self-efficacy. If people gain successful experience because of outside factor, such as luck or helped by other, there will be no enhancement of self-efficacy; however, if people gain successful experience because of self-efficacy, such as hardworking, there will be some enhancement of self-efficacy.

2. Vicarious experiences

Others' successful experiences that have similarity with the individual will increase self-efficacy, especially to do a similar task. In this case, self-efficacy is gained by social model. However, vicarious experience will be no effect if the model has no similarity to the individual.

3. Social persuasion

Verbal encouragement from someone who are capable to persuade others and be trusted by others will increase the individual's self-efficacy.

2.3.3. Self efficacy measurement

Bandura (1997), measurement of self-efficacy has three dimensions:

1. Level

Level is confidence degree of the individual to execute a certain task. Difficulty degree will be evaluated by individuals' perception toward a certain task. This component has implication in choosing behavior based on difficulty level. Individual tends to avoid a task that they perceived as a difficult task. Zimmerman (2003) divided level into three levels:

- If individual think they can do the task successfully, they will do the task
- If individual think they are impossible to do the task, they will avoid doing the task
- If individual think the task is achievable for them, they will try and give the best effort to do the task.

2. Strength

Strength of self-efficacy refers to the resoluteness of one's conviction to perform a task. And, the stronger the self-efficacy expectancy, the greater the likelihood of selecting challenging tasks, striving despite obstacles, and successfully attaining their goal. The dimensions of self-efficacy suggest that an individual who has self-efficacy on a task which is limited to its specificity to a particular level should not be generalized across domains.

3. Generality

Generality of self-efficacy refers to its pervasiveness across behaviors and contexts. People may perceive themselves to be generally efficacious in a range of activities or only within a domain of functioning.

2.3.4. Domains of self-efficacy

There are four role processes of self - efficacy: (a) cognitive (b) motivational, (c) choice and (d) emotional processes (Bandura, 1999). This role of self-efficacy in the domains of cognitive, behavior and emotion can be measured by assessing cognitive self-efficacy, motivational self-efficacy, behavioral self-efficacy, and emotional self-efficacy.

1. Cognitive processes

Cognitive process will impact on choice of strategies, development of rules for predicting and influencing events, and efficiency and effectiveness in problem solving and decision-making (Maddux, 1995). Cognitive processes include one's ability to control over one's thoughts and mental processes.

2. Motivation

Perceived efficacy is crucial for the development and regulation of motivation. "Cognitive motivation based on goal intentions is mediated by three types of self - influences: self-evaluation, perceived self-efficacy for goal attainment, and ongoing adjustment of personal standards" (Bandura, 1990, p. 81). Among these three mediators of motivation, self-efficacy has a causal(?) influence on motivation.

4. Choice behavior

Perceived self-efficacy influences choice of goals, activities directed to attaining the goal, the amount of effort expended, and perseverance in the face of obstacles. High self-efficacy leads to setting higher goals and greater commitment to attaining them (Maddux, 1995).

5. Emotion

Self-efficacy beliefs impact on both the type and intensity of emotion with low self-efficacy to attain a goal leading to despondency. Positive effect state leads to enhanced self-efficacy. Emotional efficacy can be measured through measurement of cognitive and behavioral self-efficacy for controlling emotions, cognitive self-regulation, and for performing pleasant or mastery-related behaviors.

Conclusion

This study aims to synthesize literature about various frameworks that were developed to support about high school students' learning in the 21st century science and technology. Globalization and the knowledge economy have opened up worldwide agendas for national development. Following this, there is the emphasis on the social dimension. Much of social capital includes "learning skills" and "21st century skills", which broadly cover critical, creative and inventive thinking; information, interactive and communication skills; civic literacy, global awareness and cross-cultural skills. In addition, the challenges of teaching 21st century skills will also be highlighted. It departs from the conventional paradigm of socialization, but to help students develop attributes for a future society to come.

References

- Cho, H., Gay, G., Davidson, B. & Ingraffea, A. (2007). Social networks, communication styles, and learning performance in a CSCL community. *Computers & Education*, 49, 309–329.
- Greenhow, C. & Burton, L. (2011). Help from my “friends”: social capital in the social network sites of low-income students. *Journal of Educational Computing Research*, 45, 2, 223–245.
- O’Neill, S., Scott, M. & Conboy, K. (2011). A Delphi study on collaborative learning in distance education: the faculty perspective. *British Journal of Educational Technology*, 42, 6, 939–949., 2006.
- X. Fu, J.C. Schaefer, G. Marchionini, X. Mu Video annotation in a learning environment. *Proceedings of the Annual Meeting of the American Society for Information Science & Technology*, 43 (1) (2006), pp. 1–22
- Joke Voogt & Natalie Pareja Roblin (2012). A comparative analysis of international frameworks for 21st century competences: Implications for national curriculum policies, 308.
- Min-Hsien Lee; Chun-Yen Chang & Chin-Chung Tsai (2009). Exploring Taiwanese High School Students' Perceptions of and Preferences for Teacher Authority in the Earth Science Classroom with Relation to their Attitudes and Achievement, 1817.
- Sanson-Fisher et al. (2005). Competency based teaching: the need for a new approach to teaching clinical skills in the undergraduate medical education course
- Bandura (1997). Development and evaluation of a computer-based system for dietary management of hyperlipidemia.

Exploring the differences of the Internet-specific epistemic beliefs between Taiwanese undergraduates and high school students

Yen-Lin CHIU* & Chin-Chung TSAI

Graduate Institute of Digital Learning and Education, National Taiwan University of Science and Technology, Taiwan

*E-mail: erin0825@ms58.hinet.net

Abstract: This paper aimed to compare the differences of Internet-specific epistemic beliefs (ISEB) between undergraduates and high school students. Furthermore, the influence of age and educational level as well as other variables on the ISEB were also examined. 299 participants including 150 undergraduates and 149 high school students were surveyed with the Inter-specific epistemic questionnaire (ISEQ). The exploratory factor analysis was executed to construct the ISEQ. Four dimensions of ISEB were indentified, namely Certainty, Simplicity, Source and Justification. Further, the t-test analysis and regression were administered. The results showed that there were differences of ISEB with regard to Certainty and Justification between undergraduates and high school students. However, the variables of age and educational level cannot significantly predict any dimension of ISEB. Interestingly, the gender and experience in using the Internet for academic information searching were significant predictors of Simplicity, Source and Justification.

Keywords: Online information searching, Internet-specific epistemic beliefs, Epistemology theory, Age, Education Guidelines, formatting instructions, author's kit, conference publications

1. Introduction

The role of Internet-specific epistemic beliefs has been widely concerned in the online information searching contexts (Bråten, Strømsø, & Samuelstuen, 2005; Cheng, Liang, & Tsai, 2013; Chiu, Liang, & Tsai, in press). Learners' beliefs about the Internet-based knowledge and knowing have been linked to their Internet-specific self-efficacy, online academic help seeking, self-regulated learning, and Internet-based learning activities (Cheng & Tsai, 2011; Chiu, Liang, & Tsai, in press; Strømsø & Bråten, 2010). However, the influence of age and education on the Internet-specific epistemic beliefs has not been investigated. According to Schomer's (1998) viewpoint, adults' education and age may predict their epistemic beliefs. Therefore, the aim of this study was to explore the role of age and educational level in high school students' and undergraduates' Internet-specific epistemic beliefs (ISEB). The differences of ISEB and Internet-based academic information searching behaviors between high school students and undergraduates were examined.

2. Methods

2.1 Participants

The participants of this study were 150 undergraduates and 149 high school students, of them 156 are males and 143 were females. The average age for high school students and undergraduates was 17.1 (SD = 0.87, ranged from 16 to 19) and 21.48 (SD = 1.75, ranged from 19 to 26). In all, 65.6% reported that they used the Internet for more than 10 hours per week. Most (64.5) of them also reported that they used the Internet for academic information searching at least once a week.

2.2 Measures

While administering the survey, all participants were requested to recall their experiences in doing their course-related assignments online and to respond the questionnaire by assessing their perceptions of academic information searching activities on the Internet. The Internet-Specific Epistemic Questionnaire (ISEQ) was utilized to assess the participants' beliefs relating to Internet-based knowledge and knowing. The original ISEQ was developed by Bråten and his colleagues (2005) and was translated into Chinese by Chiu and her colleagues (2013). Based on Hofer and Pintrich's (1997) 4-dimension model of epistemic beliefs, the ISEQ was validated and constructed as a 4-factor Internet-specific epistemic model, namely certainty of Internet-based knowledge, simplicity of Internet-based knowledge, source of Internet-based knowledge and justification for Internet-based knowing (Chiu et al., in press).

The ISEQ was evaluated with a 7-point Likert scale from strongly disagree to strongly agree. The higher scores for all of the four factors revealed more advanced beliefs regarding the Internet-based knowledge and knowing. Students with high scores on certainty of Internet-based knowledge were more likely to doubt the accurateness of course-related information found on the Internet. Respondents with high scores on simplicity of Internet-based knowledge intended to question that the knowledge located on the Internet is specific and simple. Participants who had higher scores on source of Internet-based knowledge were inclined to doubt that the Internet contains essential and correct information. Respondents holding high scores on justification for Internet-based knowing were more likely to believe that knowledge claims on the Internet should be justified with multiple sources.

2.3 Analysis procedure

The descriptive statistics were calculated to capture the characteristics of the participants. To validate the ISEB questionnaire, the exploratory factor analysis was conducted to eliminate the in appropriated measure items and to construct the factors of ISEB. Finally, the hypotheses were tested by administering the t-test and regression analysis.

3. Results

3.1 Results of exploratory factor analysis

While executing the EFA, the Kaiser-Meyer-Olkin (KMO) measure and the Bartlett's test of sphericity were examined to determine whether the sample was appropriate for such analysis. To construct the ISEQ, an EFA with the principle component analysis and a varimax rotation was administered to clarify its dimensionality. The eigen value larger than one was used as standard to identify the factors of ISEQ. To determine the appropriate items, items with a factor loading smaller than 0.40 or with cross-loadings were omitted

In this study, it was reported that the KMO measure had a value of 0.84 with a significant Bartlett's test (chi-square = 3012.73, $p < 0.001$). As a result, the items were grouped into four factors, namely Certainty, Simplicity, Source, and Justification. The Cronbach's alpha for these factors were 0.89, 0.81, 0.91 0.88, respectively, suggesting that these factors had high reliability. As shown in table 1, a total of 16 items are retained in the ISEQ, and the total variance explained is 74.17%, implying the ISEQ was appropriate for assessing the participant' Internet-specific epistemic beliefs.

Table 1: Factor loadings of ISEQ.

	Justification	Certainty	Simplicity	Source
JU1	0.89	0.04	-0.16	-0.03
JU2	0.88	0.07	-0.14	0.02
JU3	0.86	0.06	-0.20	-0.02
JU4	0.84	0.01	-0.14	-0.06

CE1	0.09	0.90	0.11	0.15
CE2	0.05	0.88	0.12	0.15
CE3	0.03	0.84	0.11	0.05
CE4	0.01	0.80	0.11	0.07
SP1	-0.10	0.15	0.86	0.22
SP2	-0.12	0.12	0.82	0.22
SP3	-0.28	0.13	0.79	0.21
SP4	-0.29	0.13	0.75	0.14
SO1	0.00	0.09	0.12	0.86
SO2	0.06	0.25	0.14	0.82
SO3	-0.19	-0.07	0.21	0.73
SO4	0.04	0.18	0.27	0.67

3.2 Results of t-test analysis

To compare the differences of ISEB between the high school students and undergraduates, the t-test analyses were executed. As presented in table 2, the high school students have significantly higher score on *Certainty* than the undergraduates do. On the contrary, comparing with high school students the undergraduates have significant higher score on *Justification*.

Table 2: Comparisons of ISEB between high school students and undergraduates.

Dimensions	high school		undergraduate		<i>t</i>	<i>p</i> value
	Mean	SD	Mean	SD		
Certainty	5.025	1.251	4.662	1.266	2.497	.013
Simplicity	3.545	1.100	3.368	1.055	1.420	.157
Source	3.574	0.987	3.475	1.082	.825	.410
Justification	5.295	1.011	5.628	0.796	-3.162	.002

3.3 Results of regression analysis

To explore the influence of age and educational level on the ISEB, the regression analyses were conducted. Table 3 shows the results of regression analysis for *Certainty*. As presented in table, the variables of age and educational level cannot significantly predict the tendency of Certainty, while gender significantly predicts the epistemic beliefs regarding Certainty.

Table 3: Regression results for Certainty.

Variables	Unstandardized Coefficients		Standardized Coefficients β	<i>t</i>	<i>p</i> -value
	B	Std. Error			
(Constant)	6.10	0.93		6.53	.000
Group	-0.03	0.34	-0.01	-0.09	.926
gender	0.39	0.15	0.15	2.64	.009
Age	-0.15	0.08	-0.30	-1.83	.068
Educational years	0.04	0.11	0.08	0.42	.676
Hours	0.04	0.08	0.03	0.48	.634
Experience	0.03	0.11	0.02	0.32	.749
Frequency	0.04	0.09	0.03	0.42	.675

Note:

Group: 1 for high school student, 2 for undergraduates; Gender: 1 for male, 2 for female; Hours (weekly hours for Internet usage); Experience (experience in using the Internet for academic information searching); Frequency (frequency of using the Internet for course-related assignments)

Table 4 represents the results of regression analysis for *Simplicity*. As a result, the variable of age and educational level do not predict the Simplicity; however, the gender and experience in using the Internet for academic information do significantly predict the beliefs relating to Simplicity.

Table 4: Regression results for Simplicity.

Variables	Unstandardized Coefficients		Standardized Coefficients	<i>t</i>	<i>p</i> -value
	B	Std. Error	β		
(Constant)	3.70	0.79		4.67	.000
Group	0.32	0.29	0.15	1.12	.263
gender	0.35	0.12	0.16	2.83	.005
Age	0.06	0.07	0.15	0.94	.348
Educational years	-0.17	0.09	-0.36	-1.84	.066
Hours	0.02	0.06	0.03	0.35	.725
Experience	-0.23	0.09	-0.17	-2.49	.013
Frequency	0.07	0.08	0.06	0.86	.393

Note:
Group: 1 for high school student, 2 for undergraduates; Gender: 1 for male, 2 for female; Hours (weekly hours for Internet usage); Experience (experience in using the Internet for academic information searching); Frequency (frequency of using the Internet for course-related assignments)

The results of regression analysis for Source are presented in table 5. As shown in table 5, the variable of age and educational level do not predict the Source, while the gender is a significant predictor of the beliefs with regard to Source.

Table 5: Regression results for Source.

Variables	Unstandardized Coefficients		Standardized Coefficients	<i>t</i>	<i>p</i> -value
	B	Std. Error	β		
(Constant)	4.26	0.75		5.66	.000
Group	0.46	0.27	0.22	1.67	.096
gender	0.48	0.12	0.23	4.11	.000
Age	0.00	0.06	-0.01	-0.04	.967
Educational years	-0.14	0.09	-0.30	-1.58	.114
Hours	0.08	0.06	0.10	1.35	.179
Experience	-0.14	0.09	-0.11	-1.64	.101
Frequency	0.00	0.08	0.00	-0.03	.976

Note:
Group: 1 for high school student, 2 for undergraduates; Gender: 1 for male, 2 for female; Hours (weekly hours for Internet usage); Experience (experience in using the Internet for academic information searching); Frequency (frequency of using the Internet for course-related assignments)

Table 6 displays the regression results for Justification. As presented in table 6, the variable of age and educational level do not significantly predict the Justification but the experience significantly predict the beliefs regarding the Justification.

Table 6: Regression results for Justification.

Variables	Unstandardized Coefficients		Standardized Coefficients	<i>t</i>	<i>p</i> -value
	B	Std. Error	β		
(Constant)	4.61	0.67		6.85	.000
Group	0.16	0.24	0.09	0.68	.500
gender	0.05	0.11	0.03	0.48	.635
Age	-0.04	0.06	-0.12	-0.72	.471
Educational years	0.01	0.08	0.02	0.13	.897
Hours	0.06	0.06	0.07	1.03	.306
Experience	0.25	0.08	0.22	3.24	.001
Frequency	0.02	0.07	0.02	0.36	.721
Note: Group: 1 for high school student, 2 for undergraduates; Gender: 1 for male, 2 for female; Hours (weekly hours for Internet usage); Experience (experience in using the Internet for academic information searching); Frequency (frequency of using the Internet for course-related assignments)					

Acknowledgements

This study was supported by the National Science Council, Taiwan, under grant number NSC-99-2511-S-011-005-MY3 and NSC-100-2511-S-011-004-MY3.

References

- Bråten, I., Strømsø, H. I., & Samuelstuen, M. S. (2005). The relationship between Internet-specific epistemological beliefs and learning within Internet technologies. *Journal of Educational Computing Research*, 33, 141-171.
- Cheng, K. H., & Tsai, C. C. (2011). An investigation of Taiwan University students' perceptions of online academic help seeking, and their web-based learning self-efficacy. *Internet and Higher Education*, 14, 150-157.
- Cheng, K. H., Liang, J. C., & Tsai, C. C. (2013). The role of Internet-specific epistemic beliefs and self-regulation in high school students' online academic help seeking: A structural equation modeling analysis. *Journal of Educational Computing Research*, 48, 469-489.
- Chiu, Y. L., Liang, J. C., & Tsai, C. C. (in press). Internet-specific epistemic beliefs and self-regulated learning in online academic information searching. *Metacognition and Learning*.
- Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research*, 67(1), 88-140.
- Strømsø, H. I., & Bråten, I. (2010). The role of personal epistemology in the self-regulation of internet-based learning. *Metacognition and Learning*, 5(1), 91-111.
- Schommer, M. (1998). The influence of age and education on epistemological beliefs. *British Journal of Educational Psychology*, 68, 551-562.

The Effect of Challenging Game on Students' Motivation and Flow Experience in Multi-touch Game-based Learning

Cheng-Yu HUNG^{a*}, Chih-Yuan Jerry SUN^b & Pao-Ta YU^a

^a*Department of Computer Science and Information Engineering, National Chung Cheng University, Taiwan, R.O.C.*

^b*Department of Institute of Education, National Chiao Tung University, Taiwan, R.O.C.*

*hcy98p@cs.ccu.edu.tw

Abstract: Advancements in technology have led to the continuous innovation of learning methods for students. Specifically, the use of multi-touch interfaces applied to game-based learning has been shown to be effective in attracting students' interest and increasing their desire for participation. In this paper, we used a multi-touch game, an iPad app called Motion Math, to help students learn and put into practice the mathematical concepts of addition and subtraction. Based on findings from a pilot study, we categorized the game's 18 levels of difficulty into challenging (experimental group) and matching (control group) games. We aimed to investigate whether the challenging games were better able to improve the students' motivation and flow experience in the experimental group as compared to that of the control group. The findings showed that the students in the experimental group achieved greater improvements in terms of flow learning experience.

Keywords: Digital game-based learning, flow experience, multi-touch interface, learner motivation

1. Introduction

Research has shown that integrating multi-touch interfaces with computer games facilitates positive intuitive interactions between humans and computers and in turn helps students become actively engaged in game-based learning activities (Ardito et al. 2013). A multi-touch interface allows students to move virtual objects in the scene by tapping on and dragging them (Rösler, 2009; Furió et al. 2013), which makes the game more engaging (Ardito et al. 2013). In their study, Furió et al. (2013) found that students prefer the multi-touch interface experience of an iPhone game to traditional learning games such as labyrinth games and worksheets. However, little research has investigated the benefits of integrating a multi-touch interface into computer games, or examined how multi-touch interfaces promote student learning. This study aims to address that gap, investigating the effect of challenging games on student motivation and flow experience through multi-touch game-based learning.

In recent years, an increasing number of teachers have endeavored to integrate educational computer games into training and teaching (Furió et al. 2013) because they perceive computer games to be an effective means to help students construct knowledge (Wang and Chen, 2010). In addition, educational computer games have been suggested as a tool to increase students' intrinsic motivation and levels of interest in learning (Huizenga et al., 2009; Dickey, 2007; Papastergiou, 2009). Previous studies have indicated that computer games can entertain, instruct, change attitudes, and enable the skill development of students (Alessi and Trollip 2001; C.-T. Sun et al. 2011). In addition, Liu and Lin (2009) found that student learning could be improved by providing learners with appropriately targeted educational computer games. Therefore, one of the purposes in this study was to assess students' levels of knowledge and skills with computer games in order to identify the proper difficulty levels that would enable students to improve their learning outcomes.

Digital game-based learning provides students with a problem-solving environment (Wang and Chen 2010) that may facilitate discovery learning (Kiili 2005). The characteristics of the gaming environment—such as offering interactional opportunities for users to explore and move the objectives—help learners use discovery learning to discover new rules and ideas instead of memorizing

them. In turn, students shift their motivation from extrinsic to intrinsic perspectives (Kiili 2005). Researchers have emphasized the importance of providing learning supports for game-based problem-solving learning activities. Such supports improve the learning performance of students while engaging them in an enjoyable learning process (Hwang, Wu and Chen, 2012; Wang and Chen 2010). Wang and Chen's (2010) research suggested a "matching" game strategy, which clarifies concepts by prompting learners to match correct answers and select correct items or calculations from a list of possible answers. This study further explores the strategies of integrating such activities with game-based learning and examines their effect on student learning. In addition, it offers a comparison of matching games with those requiring strategies that are more conceptually complex, which we call "challenging" games.

To facilitate students' motivation and flow experience, this study proposed two types of games, challenging games and matching games, for conducting multi-touch game-based learning. It was hypothesized that students would experience full involvement, concentration, and enjoyment in the multi-touch game-based learning environment by participating in the iPad app *Motion Math*. The following research questions are investigated in this study. A brief conceptual model of the research is shown in Figure 1.

- 1) Are there differences in student motivation and flow experience depending on whether students played challenging or matching games?

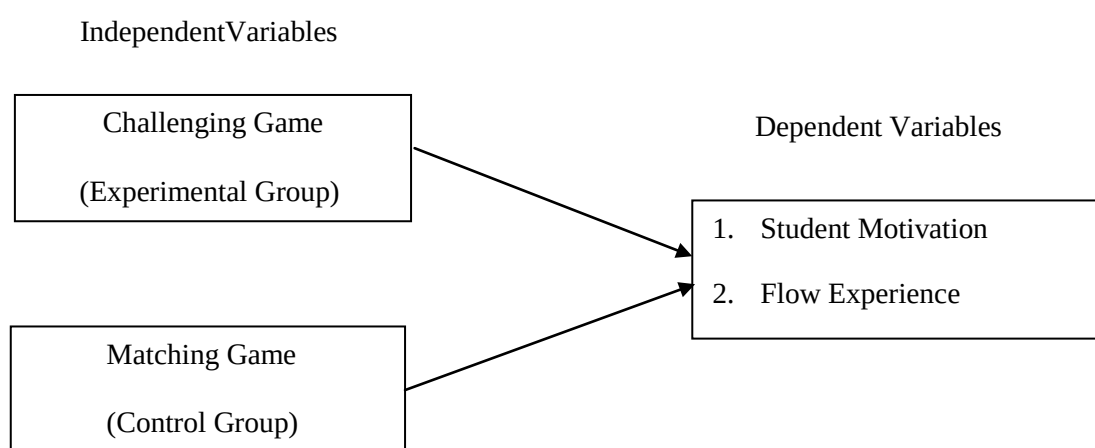


Figure. 1 Model of research questions

2. Literature Review

2.1 Flow Experience and Students' Motivation

"Flow" refers to the optimal experience of individuals who are deeply involved in an activity with full involvement, concentration and enjoyment (Hwang, Wu and Chen, 2012). During such an optimal experience, students are in a psychological state in which they are so highly involved with the task-driven activity that nothing else seems to matter (Csikszentmihalyi 1975). Previous research has shown that the flow state has a positive impact on learning (Webster, Trevino and Ryan, 1993), enhancing students' motivation to play the game; and these impacts should be taken into account when designing educational computer games (Kiili 2005). Moreover, several studies have investigated design features that enhance learning engagement and motivation by measuring students' flow experiences in game-based learning contexts (Inal and Cagiltay 2007). Games can incorporate strategies to increase players' flow experience, increase their engagement, and improve their learning outcomes (Kiili 2005).

Hwang, Wu and Chen (2012) proposed that the flow experience includes four dimensions: flow antecedent, flow experience, intrinsic motivation, and extrinsic motivation. Flow antecedent includes

focused attention (Hoffman and Novak 1996), clear goals, unambiguous feedback (Chen et al. 1999), potential control (Finneran and Zhang 2003), a perception of challenges that are matched to the person's skills (Chen et al. 1999), playfulness (Webster, Trevino and Ryan, 1993), and speed and ease of use (Skadberg and Kimmel 2004). Flow experience includes a merging of action and awareness, concentration, a sense of control over the activity (Chen et al. 1999), time distortion, and telepresence (Finneran and Zhang 2003). The flow experience leads to improved learning outcomes (Skadberg and Kimmel 2004), increased exploratory behavior (Webster, Trevino and Ryan, 1993), an acceptance of information technology (Hwang, Wu and Chen, 2012), and perceived behavioral control (Kiili 2005).

The present study measures the aforementioned flow experience in each of the four dimensions proposed by Hwang, Wu and Chen (2012): flow antecedent, flow experience, intrinsic motivation, and extrinsic motivation.

2.2 Game-Based Learning

Kinzie and Joseph (2008) claimed that “a game is an immersive, voluntary and enjoyable activity in which a challenging goal is pursued according to agreed-upon rules.” Previous studies (Brom, Preuss, and Klement, 2011; Huang, Huang, and Tschopp, 2010; Hwang, Sung, et al., 2012; Hwang, Wu, et al., 2012) have emphasized the potential for employing digital educational games in improving the students' learning performance. For instance, studies have shown that digital games play important roles in the development of children's cognition and social processes (Yien, Hung, Hwang, and Lin, 2011). Researcher (Ebner and Holzinger, 2007) have reported that educational computer games can improve students' interest in learning, and in turn increase their learning motivation (Burguillo 2010; Dickey 2011).

Wang and Chen (2010) found that the challenging games enable learners more challenging and engaging in gaming activities, allowing them to better feel the game's flow experience, while no significant improvement was found in terms of flow antecedent. Moreover, they are often used in programming training instead of the training for mathematics. However, studies have indicated that the iPhone game was lead to at least equivalent learning outcome as the traditional game and children prefer the iPhone game (Furió, et al. 2013). Therefore, the use of multi-touch interface in educational settings may help students actively engaged in game-based learning activities. Inal and Cagiltay (2007) further examined the flow experiences of children in an interactive social game environment, and results revealed that the challenge and complexity elements of the games had a greater effect on the flow experiences of the children than clear feedback.

From these studies, it was found that educational computer games have become a widely-discussed research issue. Therefore, research on improving the effectiveness of educational computer games remains an important and challenging topic.

3 Methodology

3.1 Research Design

In this study, we used Motion Math, a pleasurable learning game that has fun for young student, to conduct finger-touch game-based learning activities. Figure 2 shows the example of the game, we used this game to help students train their mental addition and subtraction. Motion Math was developed by a game design studio in San Francisco, emphasizing developing fun and engaging iPad and iPhone games to train children mental arithmetic skills. Past research (Riconscente 2011) reported that Motion Math improved test scores and also found that students' confidence towards math problems improved after playing the games. Motion Math inverts mathematical instruction to teach conceptual knowledge. The addition and subtraction in this game described as follows: If the fish is labeled as 18, there are several ways to get the addition equation such as $8+10$, $7+11$, and $9+9$. Similarly, if the fish is labeled as 32, the ways to get the subtraction equation may be $34-2$, $42-12$, or $51-19$. During the gaming process, tapping the screen gets the fish to chomp on bubbles with the different numbers, and the points are collected accordingly. Part of the fun comes from adding a visceral component to math instruction. As a result,

students learn the process by which they can reach an answer, instead of just memorizing a bunch of number combinations.

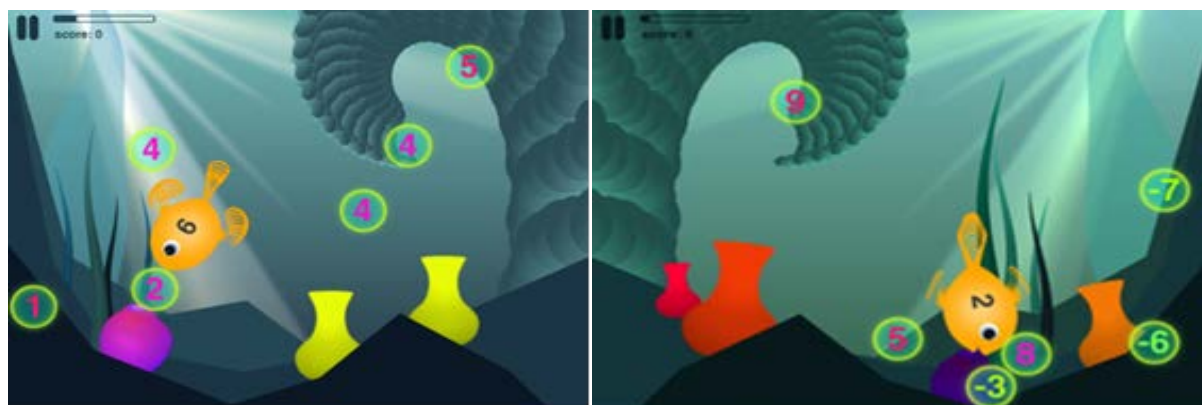


Figure2. Example of a motion math

As suggested by kiili (2005), this game provides a frame story: your fish is hungry, and hungry for numbers (see Figure 2). This fun addition and subtraction game for iPad, iPhone, and iPod touch has instant addition and subtraction, by finger touch two numbers together to instantly add or subtract. Most addition or subtraction games teach in the form of $3 + 4 = \underline{\quad}$ or $9 - 2 = \underline{\quad}$, while this game challenges players to find different ways to make a 7 (e.g. $1+6$, $2+5$, $3+2+2$, or $8-1$, $10-3$, $18-11$). The purpose is to encourage players to look for different ways to make a solution and in turn facilitate the discovery learning process and construct their own knowledge and shows of hierarchically-ordered intellectual skills. There are 18 levels of challenges (for 4-year-olds to adults) and bonuses to customize your fish with new colors and fins. These levels can be adjusted to provide the learners with more challenging and engaging to enhance their perception of the game flow experience. Details of these levels are described as follows: 1) Difficulty 1: Number Matching, 2) Difficulties 2-6: Basic addition or subtraction (not including addition with carrying and subtraction with borrowing), 3) Difficulties 5-14: Bigger number, faster gameplay (including addition with carrying and subtraction with borrowing), and 4) Difficulties 11-18: Challenging, even for adults (including addition with carrying and subtraction with borrowing, and higher degree of computational complexity).

After the student calculates the correct number, the fish eats the correct number and grows larger. Once the fish grows to a certain size, the student progresses to the next level. Conversely, if the student does not calculate the correct number or miscalculates, the fish cannot eat the correct number and it becomes increasingly small. Consequently, the student fails the level. The higher the difficulty level of the game, the faster the speed, and the shorter the time students have for calculating the results.

3.2 Polity Study

Based on pilot study results, we defined Levels 1 to 6 as matching games (control group) and Levels 7 to 14 as challenging games (experimental group). During the process of the matching games, students are able to clarify concepts through matching correct answers and selecting correct items or calculations, while in a challenging game, students are able to consolidate and elaborate concepts through progressive challenges were employed by means of limited time for task completion, levels of performance and cumulated scores for learners to challenge themselves in identifying correct concepts and examples, upgrade their levels of performance and gain higher scores (Wang and Chen, 2010).

3.3 Participants

Of the 52 second-grade students attending a school in northern Taiwan who participated in this study, 50% ($n = 26$) were in the experimental group, and 50% ($n = 26$) were in the control group. Female students ($n = 28$) represented 53.8% of the participants in this study. The mean age was eight years. All of the students were taught by the same instructor, who had more than two years of experience teaching science.

3.4 Experimental Procedure

Before the experiment, the two groups of students were given a 60-minute lesson on the basics of addition and subtraction as a part of their existing course in mathematics and science. Before beginning the game activity, the students were also taught how to operate the multi-touch app Motion Math and instructed on game rules, including how to operate the system with multi-touch gestures.

During the learning activity, the students in the experimental group participated in the challenging learning activities while those in the control group undertook the matching learning activities. Students were also videotaped during the exercise to enable later behavioral characterizations (see Discussion below).

After the learning activity, the students took the post-test and completed a second questionnaire exploring their learning motivation and flow experience.

3.5 Research Tools

The instruments in this study included a questionnaire for measuring students' motivation and flow experience. All of the survey instruments used a 6-point Likert-type scale, ranging from 1 (strongly disagree) to 6 (strongly agree).

The questionnaire on flow experience was adapted from the measurement developed by Hwang et al. (2012b). It consists of 14 items in four dimensions; that is, four items for "flow antecedent" (e.g., "The goals of the game were clearly defined"); four items for "flow experience" (e.g., "My attention was focused entirely on playing the game"); three items for "intrinsic motivation" (e.g., "In a class like this, I prefer course material that really challenges me so I can learn new things"); and three items for "extrinsic motivation" (e.g., "I want to do well in this class because it is important to show my ability to my family, friends, employer, or others"). The internal consistency coefficient (Cronbach's Alpha) values on each of the four dimensions were 0.75, 0.80, 0.82, and 0.72, respectively.

4. Research Results

4.1 Analysis of Flow Experience

Independent sample *t*-tests revealed significant differences in students' flow experience between the experimental and the control groups ($t(41) = 2.17, p < .05$). Specifically, students in the experimental group had significantly higher flow experience ($M = 5.58, SD = .36$) than that in the control group ($M = 5.27, SD = .57$), indicating possible benefits of using challenging games to increase students' flow experience. The results of the *t*-tests are presented in Table 2. Consistent with previous studies, challenge, control and enjoyment were found to be key factors related to flow experience during the gaming process (Kiili 2005; Wang and Chen 2010). Similar to the benefits of traditional games, the aforementioned factors can be activated by providing immediate and appropriate feedback, unambiguous goals and dynamic challenges (Csikszentmihalyi 1991; Kiili 2005). Therefore, the challenging game may situate students in the flow state when they are more engaged in the multi-touch game-based learning activity and more actively enjoying the process. In terms of the four dimensions of flow experience, there were statistically significant differences in flow antecedent ($t(41) = 2.47, p < .05$) and flow experience ($t(41) = 2.21, p < .05$), but no statistically significant differences were found in intrinsic motivation ($t(41) = .87, p > .05$) or extrinsic motivation ($t(41) = -0.32, p > .05$). The results of the *t*-tests are presented in Tables 2 and 3.

Table 2: *t*-Test result of flow experience of the two groups.

Group	<i>N</i>	Mean	S.D.	<i>t</i>
Experimental group	22	5.58	0.36	2.17*
Control group	21	5.27	0.57	

* $p < 0.05$.

Table 3: *t*-Test result of the four aspects of flow experience.

	Group	<i>N</i>	Mean	S.D.	<i>t</i>	
Flow antecedent	Experimental	22	5.86	0.25	2.47*	
	Control	21	5.39	0.86		
Flow experience	Experimental	22	5.70	0.39	2.21*	
	Control	21	5.23	0.94		
Intrinsic motivation	Experimental	22	5.32	0.88	0.87	
	Control	21	5.05	1.14		
Extrinsic motivation	Experimental	22	5.29	0.86	- 0.32	
	Control	21	5.37	0.75		

* $p < 0.05$.

One way to measure flow experience is to observe the behaviors of people experiencing flow (Admiraal et al. 2011). In this study, we used videotaped data to observe and count students' behavioral indicators of distraction, such as chatting with other students or looking around the room, over a forty-minute period. The experimental results reveal that the students in the experimental group ($M = 7.25$) showed less evidence of distraction than those in the control group ($M = 25.5$), indicating that the challenging games help students focus on learning activities. Results of the in-class observations are shown in Figure 3.

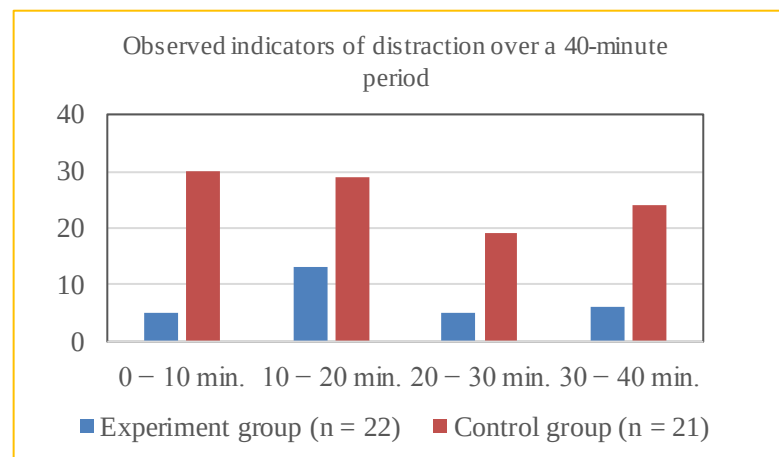


Figure 3. Distraction rates by group

5. Discussion and Conclusion

The experimental results of this comparison reveal that the challenging game is better than the matching game for improving flow learning experience, suggesting that students tend to focus on learning activities featuring intense involvement, concentration, and enjoyment. In contrast, students playing the matching game reported less immersive and possibly less enjoyable experiences during the experiential gaming process. In educational contexts, deep absorption in the immersive flow of gaming activities has been found to promote optimal learning experiences (Admiraal et al. 2011).

This study represents an important development, investigating similar questions through the multi-touch interface of the iPad, which involves a quite different form of interactive learning activity—that is, multi-touch game-based learning. Furthermore, studies comparing challenging games and matching games (Wang and Chen 2010) have so far focused on programming training in traditional game-based learning environments without multi-touch interfaces. As technology advances, students

and learning methods are changing (Furió et al. 2013), and one of the major contributions of this study is that it uses similar means for mathematical training, but combines it with a multi-touch interface to produce an innovative, effective and enjoyable learning activity.

This study examined students' use of a digital education game with a multi-touch interface. The general objective was to induce students to develop their learning motivation through a medium that could capture and hold their attention and engage them in the learning process. Recently, this method of developing students' performance has grown in popularity throughout the field of educational research (Ardito et al., 2013; Furió et al., 2013). In their evaluations of the gaming process, students reported that experiencing an interactive learning approach in a classroom environment made them feel engaged and satisfied. Therefore, this innovative approach appears to both create a flow learning experience.

References

- Alessi, S. M., & Trollip, S. R. (2001). *Multimedia for Learning: Methods and Development* (3rd ed.). Boston, MA: Allyn & Bacon.
- Ardito, C., Lanzilotti, R., Costabile, M. F., & Desolda, G. (2013). Integrating traditional learning and games on large displays: An experimental study. *Educational Technology & Society*, 16(1), 44-56.
- Brom, C., Preuss, M., & Klement, D. (2011). Are educational computer micro-games engaging and effective for knowledge acquisition at high-schools? A quasi-experimental study. *Computers & Education*, 57(3), 1971-1988, doi:10.1016/j.compedu.2011.04.007.
- Burguillo, J. C. (2010). Using game theory and competition-based learning to stimulate student motivation and performance. *Computers & Education*, 55(2), 566-575, doi:10.1016/j.compedu.2010.02.018.
- Chen, H., Wigand, R. T., & Nilan, M. (1999). Flow activities on the Web. *Computers in Human Behavior*, 15(5), 585-608.
- Csikszentmihalyi, M. (1975). *Beyond Boredom and Anxiety: Experiencing Flow in Work and Play*. San Francisco: Jossey-Bass.
- Csikszentmihalyi, M. (1991). *Flow: The Psychology of Optimal Experience*. New York: Harper Perennial.
- Chu, H. C., Hwang, G. J., Tsai, C. C., & Tseng, J. C. R. (2010). A two-tier test approach to developing location-aware mobile learning systems for natural science courses. *Computers & Education*, 55(4), 1618-1627, doi:10.1016/j.compedu.2010.07.004.
- Dickey, M. D. (2007). Game design and learning: A conjectural analysis of how massively multiple online role-playing games (MMORPGs) foster intrinsic motivation. *Educational Technology Research and Development*, 55(3), 253-273, doi:10.1007/s11423-006-9004-7.
- Dickey, M. D. (2011). Murder on Grimm Isle: The impact of game narrative design in an educational game-based learning environment. *British Journal of Educational Technology*, 42(3), 456-469, doi:10.1111/j.1467-8535.2009.01032.x.
- Ebel, R. L., & Frisbie, D. A. (1986). *Essentials of Educational Measurement*. Englewood Cliffs, NJ: Prentice Hall.
- Ebner, M., & Holzinger, A. (2007). Successful implementation of user-centered game based learning in higher education: An example from civil engineering. *Computers & Education*, 49(3), 873-890, doi:10.1016/j.compedu.2005.11.026.
- Finneran, C. M., & Zhang, P. (2003). A person-artefact-task (PAT) model of flow antecedents in computer-mediated environments. *International Journal of Human-Computer Studies*, 59(4), 475-496, doi:10.1016/s1071-5819(03)00112-5.
- Furió, D., González-Gancedo, S., Juan, M. C., Seguí, I., & Rando, N. (2013). Evaluation of learning outcomes using an educational iPhone game vs. traditional game. *Computers & Education*, 64, 1-23, doi:10.1016/j.compedu.2012.12.001.
- Ghani, J. A. (1995). Flow in human-computer interactions: Test of a model. In J. M. Carey (Ed.), *Human Factors in Information Systems: Emerging Theoretical Bases* (pp. 291-312). Norwood, NJ: Ablex Publishing Corporation.
- Hoffman, D. L., & Novak, T. P. (1996). Marketing in hypermedia computer-mediated environments: Conceptual foundations. *The Journal of Marketing*, 60(3), 50-68.
- Huang, W.-H., Huang, W.-Y., & Tschopp, J. (2010). Sustaining iterative game playing processes in DGBL: The relationship between motivational processing and outcome processing. *Computers & Education*, 55(2), 789-797, doi:10.1016/j.compedu.2010.03.011.
- Huizenga, J., Admiraal, W., Akkerman, S., & Dam, G. t. (2009). Mobile game-based learning in secondary education: engagement, motivation and learning in a mobile city game. *Journal of Computer Assisted Learning*, 25(4), 332-344, doi:10.1111/j.1365-2729.2009.00316.x.
- Hwang, G.-J., Wu, P.-H., & Chen, C.-C. (2012). An online game approach for improving students' learning performance in web-based problem-solving activities. *Computers & Education*, 59(4), 1246-1256, doi:10.1016/j.compedu.2012.05.009.

- Inal, Y., & Cagiltay, K. (2007). Flow experiences of children in an interactive social game environment. *British Journal of Educational Technology*, 38(3), 455-464, doi:10.1111/j.1467-8535.2007.00709.x.
- Kiili, K. (2005). Digital game-based learning: Towards an experiential gaming model. *The Internet and Higher Education*, 8(1), 13-24, doi:10.1016/j.iheduc.2004.12.001.
- Kinzie, M. B., & Joseph, D. R. (2008). Gender differences in game activity preferences of middle school children: implications for educational game design. *Educational Technology Research and Development*, 56(5-6), 643-663, doi:10.1007/s11423-007-9076-z.
- Liu, E. Z. F., & Lin, C. H. (2009). Developing evaluative indicators for educational computer games. *British Journal of Educational Technology*, 40(1), 174-178, doi:10.1111/j.1467-8535.2008.00852.x.
- Papastergiou, M. (2009). Digital Game-Based Learning in high school Computer Science education: Impact on educational effectiveness and student motivation. *Computers & Education*, 52(1), 1-12, doi:10.1016/j.compedu.2008.06.004.
- Prensky, M. (2001). *Digital Game-Based Learning*. New York: McGraw-Hill.
- Riconscente, M. (2011). Mobile learning game improves 5th graders' fractions knowledge and attitudes. Los Angeles: GameDesk Institute.
- Rosas, R., Nussbaum, M., Cumsille, P., Marianov, V., Correa, M., Flores, P., et al. (2003). Beyond Nintendo: design and assessment of educational video games for first and secondgrade students. *Computers & Education*, 40(1), 71-94.
- Rösler, A. (2009). Augmented Reality Games on the iPhone. (Bachelor thesis, Blekinge Institute of Technology, 2009). Retrieved from: http://amandarosler.com/Amanda_Rosler_Augmented_Reality_Games_on_the_iPhone.pdf
- Skadberg, Y. X., & Kimmel, J. R. (2004). Visitors' flow experience while browsing a Web site: Its measurement, contributing factors and consequences. *Computers in Human Behavior*, 20(3), 403-422, doi:10.1016/s0747-5632(03)00050-5.
- Sun, C.-T., Wang, D.-Y., & Chan, H.-L. (2011). How digital scaffolds in games direct problem-solving behaviors. *Computers & Education*, 57(3), 2118-2125, doi:10.1016/j.compedu.2011.05.022.
- Wang, L. C., & Chen, M. P. (2010). The effects of game strategy and preference-matching on flow experience and programming performance in game-based learning. *Innovations in Education and Teaching International*, 47(1), 39-52, doi:10.1080/14703290903525838.
- Webster, J., Trevino, L. K., & Ryan, L. (1993). The dimensionality and correlates of flow in human-computer interactions. *Computers in Human Behavior*, 9(4), 411-426, doi:[http://dx.doi.org/10.1016/0747-5632\(93\)90032-N](http://dx.doi.org/10.1016/0747-5632(93)90032-N).
- Yien, J. M., Hung, C. M., Hwang, G. J., & Lin, Y. C. (2011). A game-based learning approach to improving students' learning achievements in a nutrition course. *Turkish Online Journal of Educational Technology*, 10(2), 1-10.

Learning Application with Collaborative Finger-Touch Game-Based Learning - A Study of iPad app in Mathematics Course

Cheng-Yu HUNG^{a*}, Chih-Yuan Jerry SUN^b & Pao-Ta YU^a

^a*Department of Computer Science and Information Engineering, National Chung Cheng University, Taiwan, R.O.C.*

^b*Department of Institute of Education, National Chiao Tung University, Taiwan, R.O.C.*

*hcy98p@cs.ccu.edu.tw

Abstract: Constant advancements in technology come innovation and changes in learning methods for students. Specifically, the combination of a multi-touch interface and the game-based learning method has been found to increase the fun experienced by students during the learning process, their motivation to learn, and their willingness to participate. In this paper, we used a finger-touch game, an iPad app called Math Frogger to help students learn and put into practice the mathematical concepts of addition, subtraction, multiplication, and division. Three game scenarios were proposed and investigate whether these scenarios were able to affects the flow experience, motivation, satisfaction, and learning performance of students and to observe whether the aforementioned four variables under the various scenarios would lead to different learning outcomes.

Keywords: Collaborative learning, game-based learning, human-computer interaction

1. Introduction

Multi-touch technology has become widely available for human-computer interaction and has, in turn, promoted the awareness of human-to-human interaction, more than awareness of personal computers, in colocated collaborative work (Hwang et al. 2011). Using a multi-touch interface in educational settings may help students to become actively engaged in game-based learning activities (Ardito et al. 2013). Researchers have found that students preferred the learning experience with an iPhone game (with multi-touch interface) over traditional games (without multi-touch interface) (Furio et al. 2013). However, more studies are needed to establish that multi-touch games in collaborative learning settings are able to promote student learning.

Recently, an increasing number of teachers have endeavored to integrate educational computer games into training and teaching (Furio et al. 2013; Roblyer 2006), because computer games are perceived as an effective means to help students gain knowledge (Wang and Chen, 2010). Educational computer games have been suggested as an intrinsic motivational tool that encourages interest and enables learners to control their own learning (Dickey 2007; Huizenga et al. 2009; Papastergiou, 2009). Previous studies have indicated that computer games can entertain, instruct, change attitudes, and develop the skills of students (Alessi and Trollip, 2001; Hwang, Wu and Chen, 2012; Sun, Wang and Chan, 2011). Digital games can support and strengthen learning in four dimensions: school achievement, cognitive abilities, learning motivation, and attention and concentration (Rosas et al., 2003).

Recent research (Admiraal et al. 2011) has indicated that collaborative game-based learning can provide a flow experience. The concept of flow is used as a framework to investigate student engagement in the process of gaming. Admiraal et al. (2011) found that the flow state has an effect on the game performance of students, but not on their learning outcome. Sung and Hwang (2013) pointed out that collaborative game-based learning improves students' self-efficacy and also enhances learning effects. The games are used in mathematics training and teaching courses. However, little research has examined whether multi-touch games in a collaborative-learning setting affect the flow experience and learning outcome of a mathematics course. Therefore, the purpose of this study was to make use of a

multi-touch game (*Math Frogger*, an iPad app) in a collaborative-learning setting, to investigate its efficacy for science and technology and the flow experience and learning performance of students in a mathematics course.

2. Theoretical Background

2.1 Collaborative Learning

Collaborative learning not only allows students to learn how to respect others, but also helps in improving learning performance (Kuo, Hwang, and Lee, 2012; Schellens and Valcke 2005). Collaboration and brainstorming can assist students in the collaborative learning group to receive an enormous amount of information efficiently, thereby helping them to generate new ideas in order to accomplish learning tasks (Lipponen, 2002). Therefore, researchers have pointed out that while improvements in student learning can be achieved by using new technology, collaborative learning methods should be used to help students develop skills for their future careers as well. In the past few years, scholars have conducted relevant research on collaborative learning and educational computer games. For example, Delucia, Francese, Passero, and Tortora (2009) have conducted experiments in universities within this learning environment in order to assess second life synchronous distance lectures. Their experimental results showed that synchronous communication and social interaction were fully supported within the virtual environment. In addition, both tutors and teachers pointed out that social interaction is the true motive of students.

Huang, Liu, and Wu (2011) pointed out that in comparison with conventional methods, learning systems that included cooperative and collaborative online games significantly improved learning performance. Admiraal et al. (2011) conducted a study within the context of collaborative game-based learning. The study involved a total of 216 participants and their flow experience was investigated through team game activities, while the game was applied in the learning of history. The results showed that flow experience influenced student performance in games, but did not influence their learning outcomes. Hummel et al. (2011) investigated how learning outcomes can be enhanced in the process of playing games by including the concept of collaboration. They found that the quality of learning outcomes can be enhanced using collaborative game-based training. Further, Sánchez and Olivares (2011) presented their results on a series of learning activities conducted using a mobile game-based learning approach that was intended to develop students' problem-solving and collaborative skills. They showed that this approach can improve student learning significantly. Hwang, Wu, and Chen (2012) further reported that promoting interactions among students during the gaming process is helpful to students in improving their learning performance.

In conclusion, it can be concluded that collaborative learning has been recognized by researchers as one of the potential approaches for developing educational computer games.

3. Methodology

3.1 Research Design

In this study, we used *Math Frogger*, an enjoyable learning game that is fun for young students, to conduct collaborative, multi-touch game-based learning. Figure 1 shows an example of the game. We used this game to help students in a mathematics course to practice their addition, subtraction, multiplication, and division skills. As suggested by Kiili (2005), this game provides a frame story: by performing basic math calculations, the heroic frog character is able to cross the lily math pond to his frog princess (see Figure. 2). *Math Frogger* keeps students entertained with its simple and enjoyable features as well as the element of the fairytale environment provided by the frame story. This game provides a stimulating learning environment to encourage students to facilitate positive and initiative interaction, and construct their knowledge through game play. The game has a large variety of numeric challenges, with colorful animations. A competitive mode allows students to play the game together.



Figure 1. Example of a Math Frogger

The Math Frogger challenges students, engaging them in an enjoyable basic math learning process. The user interface is fairly easy to use, and provides clear-cut instructions at every step to help students to master the game quickly and achieve game flow. This game improves student's math skills in an experiential gaming process. During the gaming process, if students need assistance when they are confused, learning support is available to help students to solve problems, by providing scaffolds, which facilitate the zone of proximal development (Vygotsky, 1934/1978). In addition, students must race each other (or the computer) to be the first to reach the frog princess. The race itself is the most exciting part of the app, because math problems generally offer little variety. Players are presented with two choices, that is, two lily pads, each with a different number. The number on the lily pad represents the answer to a sum. Students choose the lily pad they want the frog to hop to, and a calculator appears with which they can solve the sum.



Figure 2. Task of a math frogger

3.2 Game Scenarios

Three game scenarios were proposed in this study to engage students and better immerse them in their learning environment. The first scenario pitted students against the computer, and the party that achieved the highest level in the mathematics game would find the princess, signifying completion of the task. In the second scenario, a competition among the students, the person who completed the task fastest and most accurately would find the princess. Finally, the third scenario adopted a collaborative approach where two students would form a team to compete against the computer, allowing members of each team to discuss and calculate answers together while completing the task. The fastest team to finish all the tasks would be designated the winner. The purpose of introducing three scenarios was to bring to the students a different flow experience, motivation, satisfaction, and learning performance under each scenario. These scenarios were used to investigate the effects of flow experience,

motivation, satisfaction, and learning performance on students and to observe whether the aforementioned four variables under the various scenarios would lead to different learning outcomes.

4. Conclusion and Future Research

In this study, the purpose of having three learning scenarios was to give students different challenges so as to produce different learning outcomes. In previous studies (Admiraal et al. 2011; Sung and Hwang 2013), collaborative game-based learning was used in the teaching and learning of other subjects (such as history and ecology), but not mathematics. Therefore, we made use of a multi-touch interface and combined it with collaborative game-based learning scenarios in the teaching of mathematics to determine whether this would produce the same learning outcomes as in the previous studies. However, this study is still at an exploratory stage of research, and thus the results have not been fully verified. In future studies, we will use both qualitative and quantitative approaches to verify that the collaborative game-based learning method can produce desirable learning outcomes in students.

References

- Admiraal, W., Huizenga, J., Akkerman, S., & Dam, G. t. (2011). The concept of flow in collaborative game-based learning. *Computers in Human Behavior*, 27(3), 1185-1194.
- Ardito, C., Lanzilotti, R., Costabile, M. F., & Desolda, G. (2013). Integrating traditional learning and games on large displays: An experimental study. *Educational Technology & Society*, 16(1), 44-56.
- Delucia, A., Francese, R., Passero, I., & Tortora, G. (2009). Development and evaluation of a virtual campus on second life: the case of SecondDMI. *Computers & Education*, 52(1), 220-233.
- Dickey, M. D. (2007). Game design and learning: A conjectural analysis of how massively multiple online role-playing games (MMORPGs) foster intrinsic motivation. *Educational Technology Research and Development*, 55(3), 253-273.
- Furió, D., González-Gancedo, S., Juan, M. C., Seguí, I., & Rando, N. (2013). Evaluation of learning outcomes using an educational iPhone game vs. traditional game. *Computers & Education*, 64, 1-23.
- Hamalainen, R. (2008). Designing and evaluating collaboration in a virtual game environment for vocational learning. *Computers & Education*, 50(1), 98-109.
- Huang, W. H., Huang, W. Y., & Tschopp, J. (2010). Sustaining iterative game playing processes in DGBL: the relationship between motivational processing and outcome processing. *Computers & Education*, 55(2), 789-797.
- Huizenga, J., Admiraal, W., Akkerman, S., & Dam, G. t. (2009). Mobile game-based learning in secondary education: engagement, motivation and learning in a mobile city game. *Journal of Computer Assisted Learning*, 25(4), 332-344.
- Hummel, H. G. K., Van Houcke, J., Nadolski, R. J., Van Der Hiele, T., Kurvers, H., & Löhr, A. (2011). Scripted collaboration in serious gaming for complex learning effects of multiple perspectives when acquiring water management skills. *British Journal of Educational Technology*, 42(6), 1029-1041.
- Hwang, W. Y., Su, J. H. (2011). The study of surface computer supported cooperative work and its design, efficiency, and challenges. *Interactive Learning Environments*, 20(2), 177-198.
- Hwang, G. J., Wu, P. H., & Chen, C. C. (2012). An online game approach for improving students' learning performance in web-based problem-solving activities. *Computers & Education*, 59(4), 1246-1256.
- Kiili, K. (2005). Digital game-based learning: Towards an experiential gaming model. *The Internet and Higher Education*, 8(1), 13-24.
- Kuo, F. R., Hwang, G. J., & Lee, C. C. (2012). A hybrid approach to promoting students' web-based problem solving competence and learning attitude. *Computers & Education*, 58(1), 351-364.
- Lipponen, L. (2002, January). Exploring foundations for computer-supported collaborative learning. In *Proceedings of the Conference on Computer Support for Collaborative Learning: Foundations for a CSCL Community* (pp. 72-81). International Society of the Learning Sciences.
- Papastergiou, M. (2009). Digital Game-Based Learning in high school Computer Science education:

- Impact on educational effectiveness and student motivation. *Computers & Education*, 52(1), 1-12.
- Roblyer, M. D., & Doering, A. H. (2009). *Integrating Educational Technology into Teaching* (5th ed.). Upper Saddle River, NJ: Pearson/Merrill Prentice Hall.
- Sánchez, J., & Olivares, R. (2011). Problem solving and collaboration using mobile serious games. *Computers & Education*, 57(3), 1943-1952.
- Sung, H. Y., & Hwang, G. J. (2012). A Collaborative Game-based Learning Approach to Improving Students' Learning Performance in Science Courses. *Computers & Education*, 63, 43-51.
- Schellens, T., & Valcke, M. (2005). Collaborative learning in asynchronous discussion groups: what about the impact on cognitive processing? *Computers in Human Behavior*, 21(6), 957-975.
- Triantafyllakos, G., Palaigeorgiou, G., & Tsoukalas, I. A. (2011). Designing educational software with students through collaborative design games: the We!Design&Play. *Computers & Education*, 56(1), 227-242.
- Wang, L. C., & Chen, M. P. (2010). The effects of game strategy and preference-matching on flow experience and programming performance in game-based learning. *Innovations in Education and Teaching International*, 47(1), 39-52.
- Vygotsky, L. S. (1934/1978). *Mind in Society: The Development of Higher Psychological Processes*. Cambridge, MA: Harvard University Press.

A Courseware Developed with Toy-like Interactive Interfaces

Ping-Lin FAN ^{a*}, Hsueh-Wu WANG ^a, Su-Ju LU ^a, Chi-Shan YU ^a & Wei-Hsien WU ^b

^a *Department of Digital Technology Design, National Taipei University of Education, R.O.C.*

^b *Department of Computer Science, National Taipei University of Education, R.O.C.*

* plfan@tea.ntue.edu.tw

Abstract: The current study proposes a courseware built on game design and operated with toy-like interactive interfaces, which aims to increase students' enjoyment, and motivation. The authors developed small scale educational games with sensor-based interfaces and observed children's learning experiences when using presented novel input interfaces. The participants are 192 fourth- and sixth-grade students in Taiwan. Through the preliminary observations, this study found that toy-like interactive interfaces not only attracts the interest and gain enjoyments of children, but also stimulates their learning motivation. The findings have highlighted the value of the courseware with toy-like interfaces and indicated that the introduction of novel interfaces can be a useful tool for enhancing classroom learning activities.

Keywords: sensor-based interactive device, human-computer interface, game-based learning

1. Introduction

The rapid emergence of information technology applications has facilitated numerous attempts to provide alternatives to traditional classroom teaching by creating course materials that incorporate new information technologies, which engage learners in a more pleasant learning process (Lankshear & Knobel, 2006). Classroom teachers and researchers have explored the integration of game features into the curriculum to enhance students' interest in learning using the video and audio characteristics of digital games (Prensky, 2003). Game-based learning can effectively enhance students' learning motivation and effectiveness and the potential of using computer games as an educational tool in the classroom is promising (Oblinger, 2004 ; Paraskeva, Mysirlaki, & Papagianni, 2010).

Aunola, Leskinen and Nurmi (2006) contended that learning motivation is an important factor for learning effectiveness. Thus, teachers who try to achieve educational objectives could introduce games in curricular contents to create a courseware that would promote students' learning interest. Students could also immerse themselves in the learning situation and improve their motivation (Burgillo, 2010; Kebritchi, Hirumi, & Bai, 2010).

Recently, due to the remarkable progress in hardware/software for information technology, a significant research growth in human-computer interaction (HCI) field has been made. Instead of traditional input devices (mouse/keyboard), many novel input and output devices, such as visual-based, audio-based and sensor-based interactive devices that can realize ubiquitous computing and the multimodal human-computer interaction (MMHCI) era is coming (Jaimes & Sebe, 2007). By using sensor-based interactive technology, the current study presents a novel alternative to interact with computers and to experience learning activity with courseware designed with game contents for children.

2. Methodology

Phidgets Inc. provides a set of sensor-based devices for universal serial bus (USB) sensing and controlling to/from computers. Various supported programming languages along with an in-depth application programming interface (API) are also provided (Phidget Inc., 2013). The courseware developed in project consists of seven course units, which are designed to be interactive, that is, they

allow the users manipulate novel sensor-based devices to process each course unit of the proposed system (Figure 1).



Figure 1. A representative screenshot of the toy-like interactive devices(Bamboo pistol)developed in this study.

192 children aged 11 to 12 years from primary schools in Taiwan participated in the present study. The authors used existing questionnaires (original and modified) to create an instrument aimed at collecting data on entertainment, and immersion of the courseware operated with the toy-like interactive system. Participants were asked to answer the questionnaires upon completion of all toy-like interactive devices.

3. Conclusions

This study has observed how children interact with a toy-like interactive courseware. The results indicate that children have higher immersion and greater attention when using the toy-like interactive system. Even without special skills or any assistance, children can easily operate the proposed toy-like interactive system. The toy-like interactive system is suitable for classroom assistant teaching for elementary school students.

From the learning perspective, the authors are not only interested in human-computer interaction to interpret user actions toward a desired system's events, but also in the potential of game-based learning. In this sense, a novel interactive interface to manipulate a computer educational game has been developed in the current study. Compared to the traditional keyboard/mouse input, the proposed system fosters better learning processes from an engagement viewpoint. However, usability of the proposed system is more emphasized than learning efficiency in this study. Future research will explore more instruction design issues affecting learning performance of students with the courseware. Learning performance related topics are worth further investigation in the near future.

Acknowledgements

This research was sponsored by National Science Council of Taiwan, project numbers NSC 102-2511-S-152-018 and NSC 100-2511-S-152-011-MY2.

References

- Aunola, K., Leskinen, E., & Nurmi, J. E. (2006). Developmental dynamics between mathematical performance, task-motivation, and teachers' goals during the transition to primary school. *British Journal of Educational Psychology*, 76, 21-40.

- Burguillo, J. C. (2010). Using game theory and competition-based learning to stimulate student motivation and performance. *Computers & Education*, 55(2), 566–575.
- Cordes, C. & Miller, E. (2002). Fool's gold: A critical look at computers in childhood. College Park, Alliance for Childhood. Retrieved from http://www.allianceforchildhood.net/projects/computers/computers_reports_fools_gold_contents.htm
- Jaimes, A. & Sebe, N.(2007), Multimodal human-computer interaction: A survey. *Computer Vision and Image Understanding*, 108(1-2), 116-134.
- Kebritchi, M., Hirumi, A., & Bai, H. Y. (2010). The effects of modern mathematics computer games on mathematics achievement and class motivation. *Computers & Education*, 55(2), 427–443
- Lankshear, C., & Knobel, M. (2006). *New literacies: Everyday practices and classroom learning*. Maidenhead, Berkshire: McGraw Hill/Open University Press.
- Oblinger, D. (2004). The next generation of educational engagement. *Journal of Interactive Media in Education*, 1-18.
- Paraskeva, F., Mysirlaki, S., & Papagianni, A. (2010). Multiplayer online games as educational tools: Facing new challenges in learning. *Computers & Education*, 54(2), 498–505.
- Phidgets Inc. (2013). Products for USB Sensing and Control. Retrieved from <http://serc.carleton.edu/introgeo/games/index.html>
- Prensky, M. (2003). Digital game-based learning. *ACM Computers in Entertainment*, 1(1), 1-4.
- Subrahmanyam, K., Kraut, R. E., Greenfield, P. M. & Gross, E. F.(2000), The impact of home computer use on children activities and development. *Children and computer technology*, 10 (2), 123-144.

Investigating Students' Sequence of Mathematical Topics in an Educational Game with a Curriculum Map

Hercy N.H. CHENG*, Charles Y.C. YEH, Hui-Wen WU, Calvin C.Y. LIAO,
Andrew C.-C. LAO & Tak-Wai CHAN

Graduate Institute of Network Learning Technology, National Central University, Taiwan

*hercy@CL.ncu.edu.tw

Abstract: Spiral curriculum is suitable for students' ability development in a teacher-centered learning. In a sense, current textbooks adopt spiral curriculum because teachers need textbooks to teach their students. However, in a learner-centered learning, textbooks leave little space for students to monitor their own learning. For this reason, this study aims to design an educational game, Math Island, in which students may learn mathematics in their own paces according to their own ability. In the game, students play as a role of a city manager who needs to choose building plans and build their own building. When they build their city, actually they have to complete various learning tasks, which are designed from simple to complicated concepts. A preliminary finding suggests that students tended to carrying out learning tasks continuously instead of spirally. However, further investigation into students' learning behaviors on Math Island should be conducted.

Keywords: Curriculum map, spiral curriculum, self-paced learning, educational mathematical games

1. Introduction

In a conventional mathematical classroom, a teacher teaches mathematical concepts and assigns exercises to students, whose job is to follow the instructions and do the exercises. Almost all teachers use textbooks to teach students, because textbooks have a well-defined sequence of mathematical knowledge. With the examples and exercises in textbooks, teachers may easily prepare their teaching and tell students what to do in a class. By tests, teachers may assess whether students have learnt or not. However, although students learn the knowledge, they do not really know why they need to learn it and what they have to learn. In a sense, the domination of teachers in a classroom may hinder students from learning actively.

The major problem perhaps is the design of mathematical textbooks, which usually follows the official curriculum guideline. As the matter of fact, the curriculum guideline originated from spiral curriculum (Bruner, 1966). Furthermore, spiral curriculum provides increasing level of difficulty, which allows students to learn a new concept when they revisit a certain topic. For example, a student learns the addition of two 1-digit numbers in the first grade, and has to learn the concept of carries for adding two 2-digit numbers in the second grade. Later in the third grade, hi/she revisits the addition again and learns the addition of 3 or 4-digit numbers. Because of the property of spiral, the curriculum emphasizes the linkage between prior knowledge and the new concept. More specifically, teachers have to guide students to look back on knowledge previously learned, so that students can learn a new concept.

Nowadays, our textbooks, which embody the formation of spiral curriculum, hold the structure of mathematical knowledge, which teachers follows to lead students to learn the knowledge. However, textbooks leave little space for students to monitor their own learning, because textbooks are designed for teacher-centered learning. Teachers use textbooks to follow the standard pace of the curriculum, to demonstrate the examples, to instruct students, and to conduct exercises. In a sense, textbooks ignore the ability difference between students, which actually exists in a normal classroom. Some students who

learn well and fast can and should be allowed to learn more complicated concepts, while some students who learn badly and slowly should be taught in a careful way. In other words, students should have different learning paces depending on their unique ability.

For this reason, this study aims to design an educational game, Math Island, in which students may learn mathematics in their own paces according to their own ability. More specifically, the game allows students to explore mathematical concepts and their relationship with a curriculum map. Like spiral curriculum, the curriculum map guides students from simple concepts to complicated ones. However, the curriculum map does not force all students to follow the same pace. Instead, students may take their own paces and choose a path of the curriculum map in the game.

2. Design of Math Island

2.1 Curriculum Map

The design of curriculum map originates from curriculum tree (Chan, 1992). Curriculum tree provides a tree structure, which has several nodes and links. In a curriculum tree, each node represents certain knowledge (for example, the addition of two two-digit numbers with carries), while each link represents the linkage between two nodes of knowledge. Knowledge providers may easily add, delete, modify, and manage a curriculum. Furthermore, the feature of tree structure may visualize and organize a complex curriculum, so that teachers and students may easily make decision.

Like curriculum tree, curriculum map is also a visualized relationship between knowledge. The structure of map may allow students to explore concepts (Davenport, & Prusak, 2000). The well-structured knowledge may help students to retrieve, retain, and transfer knowledge (Davenport, de Long, & Beers, 1998). Furthermore, the structure organizes and links plenty of information visually, so that students may easily find the key information. Besides, the structure also helps them to evaluate how well they learn and adjust the way they learn.

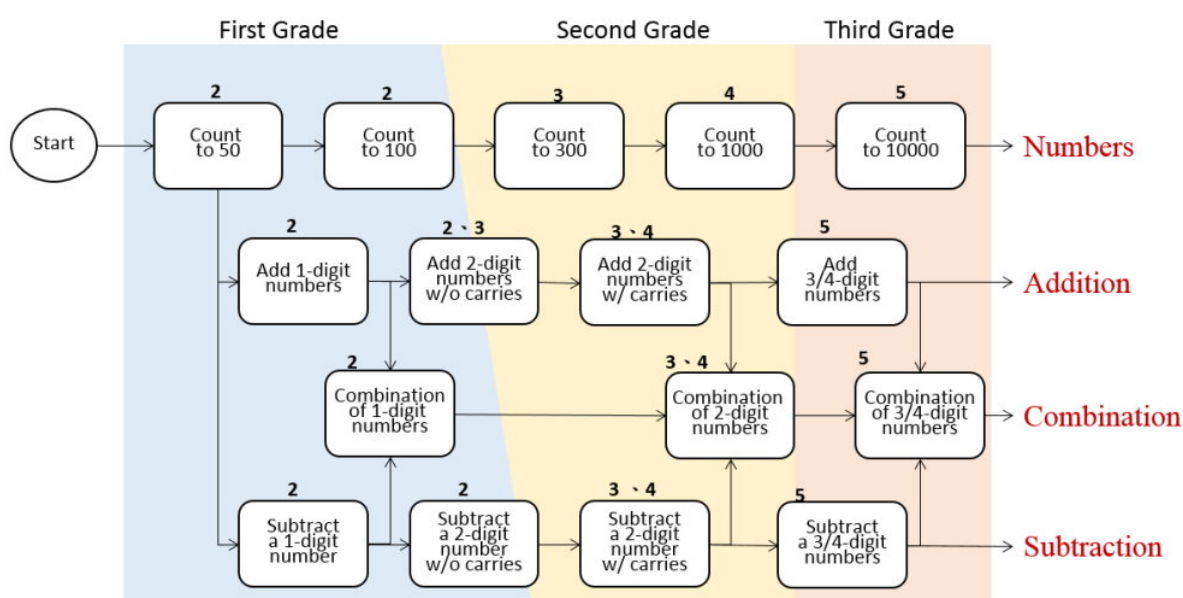


Figure 1. Curriculum Map

Figure 1 shows the design of curriculum map in the game. As shown in the figure, there are four topics of mathematical knowledge, i.e. numbers, addition, subtraction, and combination of addition and subtraction. For each topic, there are several concepts, illustrated as boxes with book numbers. For each concept, there are a series of learning tasks, which will be introduced in section 2.2 and 2.3. Take the topic of numbers for example. In the original textbook, the first grader have to learn how to count numbers to 100 in book 1 and 2 (this study only provide the concepts in book 2), while the second

grader learn how to count numbers to 1000 in book 3 and 4. However, in this curriculum map, students can learn how to count 1000 once they complete counting 100 (book 2) and 300 (book 3).

Furthermore, after they learn the concept of counting to 50, they can choose the concept of counting to 100, adding two 1-digit numbers, or subtracting a 1-digit numbers. The freedom of choice may increase learning interest. Most importantly, it encourages students to explore knowledge and to try to solve problems. Perhaps they may make mistakes, but making mistakes is also a form of learning.

2.2 Learning and Gaming Flow

Figure 2 illustrates the flow chart with three main steps for using Math Island in the perspective of learning and gaming. In the perspective of learning, students have to choose a learning task in the first step. For doing so, they first need to select a topic and a concept which they have not finished yet in the curriculum map. Then, they need to select an unfinished learning task in a specified concept. In the second step, they attempt to solve the selected learning task. There are two kinds of learning tasks: key learning tasks and practice learning tasks. A key learning task is designed for learning a new concept, while a practice learning task is designed for practicing a learnt concept. A learning task usually takes about 10 to 20 minutes. Furthermore, a learning task usually comprises several examples and exercises. If a student does an exercise wrongly, the learning task asks he/she do it again with hints if provided. In the third step, when finishing a learning task, they get feedbacks depending on their performance. Feedback may be positive or negative. Positive feedbacks help students build their sense of achievement and confidence, while negative feedbacks remind them to do it again.

In the perspective of gaming, students play as a role of a city manager. Their ultimate goal is to build a prosperous city. According to the aforementioned curriculum map, the ultimate goal is difficult for first graders, because it need taking at least two or three years. However, they can set a short-term goal when they attend a math class. More specifically, in the first step, they are required to choose a building plan, which is actually a learning task. Then in the second step they construct a part of the building by solving a learning task. Finally, when they finish the construction, they may get citizens with their taxes. Additionally, if they finish a certain number of learning tasks for a building plan, the building is enlarged and upgraded. The citizens and taxes can be used to plant more trees and to build more facilities for decorating their own cities.

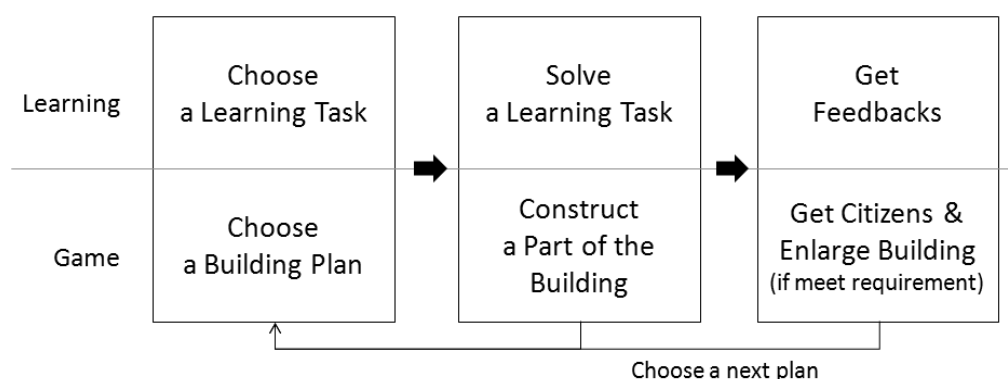


Figure 2. Learning and gaming flow

2.3 Game Design

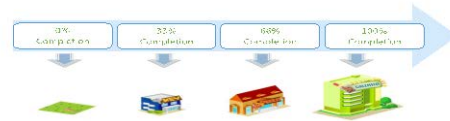
Figure 3(a) shows the main interface of a Math Island for one student. As show in the figure, the Math Island is built according to the aforementioned curriculum map. Each topic is designed as a road. For example, from the top of the figure, there are a number road, an addition road, a combination road and a subtraction road, respectively. For a road of a topic, each concept is designed as a building, which is linked by roads. The buildings should be built according to the sequence of the curriculum map.

When students finish key learning tasks in a building, they are allowed to choose to build the next building. In other words, they may choose either exploring the next concept, or continuing constructing an existed building by finishing the practice learning tasks. If they decide to construct an existed building, they have chances to upgrade the building. Figure 3(b) illustrates the requirement for

upgrading buildings. In short, every time they finish one third of learning tasks in a building, the building meets the requirement and upgrades.



(a) Game-based curriculum map



(b) Building upgrade requirement



(c) Learning tasks for a concept



(d) A learning task

Figure 3. Math Island

When students choose a building of a concept, the game shows a list of learning tasks, as illustrated in Figure 3(c). The learning tasks with a “key” are key learning tasks (Figure 3(d)), while those without a key are practice learning tasks. Furthermore, as shown in the figure, some learning tasks are “locked” because the student has not finished the previous key learning tasks. In this case, the student has finished the first three learning tasks, but has not start doing the forth, fifth and sixed learning tasks. The seventh and the eighth learning tasks are locked because the student has not finished the sixed learning task, which is the key learning task.

3. Preliminary Evaluation

The research goal in this study is to investigate students’ learning path on Math Island. More specifically, this study focuses on the sequence of mathematical topics. It would be interesting to find out whether students still learn as the spiral curriculum or as a continuous curriculum, given a complete curriculum on Math Island.

3.1 Setting

This study was conducted in a first-grade class of a primary school in Taiwan. In the class, there were 14 male and 12 female students. Each student used a tablet PC to use Math Island. Because not all students had used computers, they were taught how to use tablet PC before the study.

This study took about 12 weeks in the second semester of the first grade. In each week, students were allowed to play Math Island in at least two sessions of formal math classes and each session took about 40 minutes. Besides, they were also allowed to play the game in the rest time at school and at home. Although the teacher started to teach book 2 at that time, the Math Island provided a complete curriculum from book 2 to book 5 about numbers, addition and subtraction, as shown in Figure 1.

3.2 Sequential Analysis Approach

For investigating the sequence of mathematical topics, this study adopted sequential analysis approach (Jeong, 2005; Jeong & Davidson-Shivers, 2006), which could be used to analyzing the interaction and argumentation in an online discussion forum. This approach could reveal not only the frequencies of behaviors, but also their sequence (Kapur, 2011; Liao, Chen, Cheng, & Chan, 2012).

The study adopted sequential analysis approach to explore the sequence of students' learning behaviors, especially about how they choose mathematical topics on Math Island. For doing so, the students' behaviors on Math Island were coded in the following way. First, for each student, the sequence of learning tasks was recorded. Second, the learning tasks were categorized as four mathematical topics: numbers (N), addition (A), subtraction (S), and the combination of addition and subtraction (C). If students use Math Island as spiral curriculum, there should be significant sequences between one topic and another topic. Otherwise, there should be significant tendency for continuing the same topic.

3.3 A Preliminary Finding

Table 1 shows the frequencies of learning tasks for the first grade. As shown in the table, all students finished the learning tasks on numbers for the first grade. However, not all students finished the learning tasks on addition, subtraction, and combination. It should be noted that only 7 students started to carry out the learning tasks on combination.

Table 9. The frequencies of learning tasks for the first grade

Topic	Total Amount	Average Frequencies	Average Time (minutes)
Numbers	30	31.1	187.6
Addition	34	14.4	92.4
Subtraction	16	9.8	94.9
Combination	8	4.9	19.9

Figure 4 further illustrates the sequence of mathematical topics on Math Island. The figure shows that students tended to do the same topics after they finished a learning task ($N \rightarrow N$: 0.88; $A \rightarrow A$: 0.69; $S \rightarrow S$: 0.61; $C \rightarrow C$: 0.65). Although the current curriculum indicates students should learn mathematics via revisiting different topics spirally, this tendency suggests a more natural way that students learn mathematics continuously.

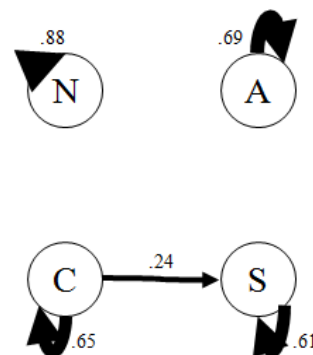


Figure 4. The sequence of mathematical topics on Math Island

Figure 4 also shows that the seven students, who started to carry out the learning tasks on the combination of addition and subtraction, tended to go back to completed learning tasks on subtraction ($C \rightarrow S$: 0.24). This result may be due to the fact that when they started to do the exercises on combination, they found that the topic was too difficult for them and they may need to strengthen their

ability of subtraction. For this reason, they decided to complete their unfinished learning tasks on subtraction. However, this conjecture needs further investigation.

4. Concluding Remarks

The textbooks nowadays adopts spiral curriculum, which may be suitable for students' ability development in a teacher-centered learning. However, it cannot allow students to realize the relationship among knowledge in a macro view. For this reason, this paper designs and develops an educational game, Math Island, on the basis of a curriculum map. In this version, the game may help the first graders explore the curriculum map, which may build core mathematical concepts and their relationship. Furthermore, the game provides learning tasks of all concepts about numbers, addition, subtraction, and combination for the first to the third graders. In the game, the students need to choose a learning task, and to adjust their direction for self-paced learning. A preliminary finding suggests that students tended to carrying out learning tasks continuously instead of spirally. However, further investigation into students' learning behaviors on Math Island should be conducted.

Acknowledgements

The authors would like to thank the National Science Council of the Republic of China, Taiwan, for financial support (NSC-101-2631-S-011-002 、 NSC-101-2511-S-008-016-MY3 、 NSC-100-2511-S-008-013-MY3 、 NSC-99-2511-S-008-002-MY3 、 NSC-101-2811-S-008-009 、 NSC-101-2811-S-008-010), and Research Center for Science and Technology for Learning, National Central University, Taiwan.

References

- Bruner, J. S. (1966). *Toward a Theory of Instruction*. Cambridge, Mass: Harvard University Press.
- Chan, T. W. (1992). Curriculum tree: a knowledge-based architecture for intelligent tutoring systems. *Intelligent Tutoring Systems*, 608, 140-147.
- Davenport, T. H., de Long, D. W., & Beers, M. C. (1998). Successful knowledge management projects, *Sloan Management Review*, 39(2), 43-57.
- Davenport, T. H., & Prusak, L. (2000). *Working Knowledge: How Organizations Manage What They Know*. Cambridge, Mass: Harvard Business Press.
- Jeong, A. (2005). A guide to analyzing message-response sequences and group interaction patterns in computer-mediated communication. *Distance Education*, 26(3), 367-383. doi:10.1080/01587910500291470
- Jeong, A., & Davidson-Shivers, G. V. (2006). The effects of gender interaction patterns on student participation in computer-supported collaborative argumentation. *Educational Technology Research and Development*, 54(6), 543-568. doi:10.1007/s11423-006-0636-4
- Kapur, M. (2011). Temporality matters: Advancing a method for analyzing problem-solving processes in a computer-supported collaborative environment. *Computer-Supported Collaborative Learning*, 6(1), 39-56.
- Liao, C. C. Y., Chen, Z. H., Cheng, H. N. H., & Chan, T. W. (2012). Unfolding learning behaviors: A sequential analysis approach in a game-based learning environment. *Research and Practice in Technology Enhanced Learning*, 7(1), 25-44.

Tailored RPG as a Supplementary Reading Pedagogy for Teaching English

Mira Luxita SARI* & Cheng-Ting CHEN
Dept. of Applied Linguistics and Language Studies,
Chung Yuan Christian University, Taiwan
*miraluxita@yahoo.com

Abstract: Even though English has become the main foreign language in Indonesia, *The Ministry of National Education* in Indonesia decided to remove English from the main subjects in elementary level due to the difficulties of teaching and learning. Hence, this study investigates the effectiveness of employing computer games as a supplementary pedagogy in English teaching to improve students' reading ability and to reduce students' learning anxiety. This study will be expected to shed the light on how to prepare creative reading materials by using computer games for English teachers, private or public schools, cram schools, and researchers. Ninety four students in a private school in west Indonesia were recruited as the participants. A mixed-research design was employed and twelve games were introduced to the students for six weeks. Moreover, a RPG workshop was presented to the English teachers for 4 weeks. Four research questions were developed, and the data were collected through pretest and posttest, classroom observation, teacher interview, and teaching reading strategy questionnaire. The results showed that the p-value of the t-test is $< .0001$, indicated that the RPG works as an effective supplemental teaching strategy. The students' English proficiency improved significantly after the RPG intervention. The result also pointed out that RPG helped the students to be more focused on their assignments. Simultaneously, the English teachers perceived that RPG increased the students' motivation to learn English. Therefore, all teachers agreed that RPG could be an alternative strategy for teaching English. They commented that RPG helped them to prepare the materials by using virtual characters to create meaningful dialogue, so the students could learn English more easily in a more interesting way. Overall, it can be concluded that RPG worked as an effective supplementary reading pedagogy in English teaching.

Keywords: Role Playing Game, language learning, English teaching

1. Introduction

Since English has become the main foreign language in Indonesia, Indonesian students have to learn English started from grade 4 (Lauder, 2008). Lately, even though there are some changes of policy regarding elementary English curriculum, English is still the most popular and most frequently used foreign language around the world. Therefore, the researcher of current study realized that English education is important major for Indonesian.

Santoso (2006) mentions that "In the context of the Indonesian multilingual society, where English is taught as a foreign language (EFL), such bilingual program has become a significant breakthrough, encouraging the use of English in non-English subjects." (p. 1). According to Rothschild (2008), the study of *The Instructional Design of an Educational Game* found that the learning outcomes by using an educational game increased 500 vocabulary words over the course of 10 levels and improved player use of word learning strategies by providing instruction and practice some activities in that game.

Moreover, the study of *The Effect of Quest Types and Gaming Motivation in Role Playing Game*, found that the bounty-collection quest (expedition to get the reward) significantly affected the procedure knowledge of subjects with high immersion motivation (Lee & Yi Chao, 2009). Consequently, this current study expects to employ computer games to improve students' reading ability as well as to reduce students' anxiety of learning English.

1.1 Purpose of the study

The purpose of this study is to explore the effects of applying RPG as a supplementary reading pedagogy for teaching English. This current research aims to explore the effectiveness of using digital role-playing games (RPGs) as a supplementary reading pedagogy in English classes. Confidently, RPG as a supplementary reading pedagogy can be a creative way to teach English in Indonesia.

1.2 Research Question

To determine the effectiveness of using tailored RPGs to support English lessons, four questions are established below:

- Can tailored RPGs improve students' reading skills?
- What are the teacher's perceptions regarding tailored RPGs?
- In what way and to what extent, tailored RPGs can assist the students' learning?
- Can RPG act as a supplementary reading pedagogy for teaching English?

2. Literature Review

2.1 RPG for Language Learning

Tychsen (2006) clearly provides an analysis of the RPG (Role Playing Game) indicating two parts, the process and the aspect of playing. All features of the RPGs show important roles in building imagination. In addition, computer games are able to facilitate the knowledge construction through the problem-solving tasks such as game quests (Lee & Yi Chao, 2009).

Moshell, Li, Makwana & McDaniel (2007) also mention that the RPG creates important relationships with language learning. The experiment also proved that there are several modes of interaction that could benefit for language learners. Therefore, their experiment can be seen as one inspiration of this study.

2.2 The Influence of Technology in Education

As Kamil, Intrator, and Kim (2000) confirm in their study, technology is highly motivational for students. Besides, computer software has been credited as an effective tool for teaching reading to students who suffer from reading difficulties.

On the other hand, McKenna, Reinking, Labbo, and Watkins (1996) also note that the interactive benefits of the computer and multimedia are that students can enjoy playing and be less frustrated when they are using the computer to improve their reading. Moreover, computers and other technology provide the practice, support, and motivation for students who have reading difficulties (Meyer & Rose, 1998).

2.3 Teachers' perceptions of computer technology as language learning

Computer assisted language learning (CALL) in language classrooms entails various issues of language teaching, such as pedagogical approaches, language skills, learning styles, students' target language proficiency levels, and motivation. Teachers identifies that computers support their integration of meaningful and authentic communication into language-teaching curriculum (Warschauer, 1996).

Meskill, Mossop, DiAngelo and Pasquale (2002) report that technologically experienced teachers tend to focus more on student learning and student empowerment than teacher instruction. Miller and Olson (1994) and Cuban (2001) also point out that the use of computers has been believed to transform teachers' pedagogical practices from teacher-centered to student-centered.

3. Method

To explore the function of RPG as a supplementary reading pedagogy for teaching English, this current study investigates the effectiveness by using four instruments to collect data. In order to answer the four

research questions, the data are collected through pretest and posttest assignments, classroom observations, teacher interviews, and teaching strategy questionnaire.

3.1 Participants

The participants of this study are beginning-level English learners in Indonesia. This current study recruits around 94 students which are divided into four classes of 4th grade from a private elementary school in Indonesia. The participants in this current study are around 9-10 years old, who were studying in the spring semester of the 2012/2013 academic year.

3.2 Material and Procedure

Twelve RPGs are created by using RPG Maker VX 1.02. The software has been purchased by the researchers' academic school department. The major treatment is 12 digital role playing games created based on the school curriculum content and the English coordinator's lesson plan. A syllabus is created to support the researcher in designing the games. The researcher creates the syllabus and lesson plan by combining the national syllabus curriculum and the school curriculum. Consequently, it needs six weeks and 12 meetings to teach the topic. Furthermore, a RPG workshop was presented to the English teachers for 4 weeks based on the teachers' request.

3.3 Pretest and posttest

This current study applied the test based on the forms that the school employed. The researcher utilized two test forms, multiple-choice and vocabulary translation, to construct the pretest and the posttest. The materials used in pretest and posttest are identical. Both tests contained 22 picture-cued tasks, 28 reading comprehension questions and 50 vocabulary words tasks. Total number of questions in the pretest and the posttest is 100. The results from the pretest and posttest were employed to answer the first research question.

3.4 Classroom observation

The researcher created seven coding criteria to analyze the observation results, such as; actively engaged in activity, self-distracted, engaged with the reading, engaged with teacher, engaged with peers, student achievement and student compliment. The researcher explored how the students learned - how they interpreted and made sense of the RPGs, when they stumbled and how they solved the problem in reading when they did not understand the materials and so on. The observation field notes were collected and analyzed to answer the second question.

3.5 Teacher Interview

A semi-structured interview was given to the English teacher to comprehend the teacher's perception of using the RPGs as an alternative strategy in the class. Ten interview questions were provided and all items were constructed in English.

3.6 Questionnaire of Reading Instruction

The researcher employed open-ended questionnaire for five English teachers in Elementary class to identify their opinions on teaching English by using RPG. The selected English teachers was chosen by the principal. Before the survey, five English teachers were trained about how to create the RPGs for English teaching. This mini workshop was conducted in March 2013 for 4 meetings. Each meeting had one discussion topic.

Moreover, seven coding criteria, "teacher personal information", "teachers' opinions regarding the RPG as an alternative strategy for learning English", "teachers' opinion regarding RPG design", "teacher opinion regarding the beneficial of using RPG", "teachers' difficulty in creating RPG" and "English teaching process by using RPG" were set by the researcher to analyze the results.

3.7 Tailored RPG & the Syllabus

The basic competency of this syllabus is to assist the students to be able to identify the vocabulary words and able to use the simple infinitive in the text. Consequently, the students should be able to comprehend the short story. The goal of the syllabus is that the students can identify the information through the reading.

The materials used in the RPG include simple dialogues, short stories and vocabulary words. The activities appeared in RPGs are to identify the meaning in the dialogues, and to identify the meaning of the vocabulary words. As to the evaluation modes in the tailored RPGs, there are multiple-choice questions and true/false questions. All the twelve games are presented by using different stories. As shown below, figure 1 is part of a virtual classroom, and figure 2 presents an example question in the TV studio setting.



Figure 1. The virtual classroom



Figure 2. A question in TV studio

3.8 Data collection and procedures

To analyze the pretest and posttest assignment results, the researcher employed paired sample t-test. All data were analyzed with the Statistical Package for the Social Sciences (SPSS) version 20. The field notes were employed in observation, and analyzed based on the seven coding criteria. The participants' reactions were also recorded by using a camera. The English teacher was interviewed by using semi-structured interview questionnaire to analyze the teacher's perception. Krueger framework analysis was employed for data analysis.

The researcher also applied the Questionnaire of Reading Instruction for five English teachers and the seven questions were analyzed by using the questionnaire coding criteria. Subsequently, the researcher connected the three of data collections; observation, interview and questionnaire into data triangulation.

4. Results & Discussion

Researcher describes the findings according to four research questions: pretest and posttest assignment, teacher interview, classroom observation and Teaching Reading Strategy Questionnaire.

4.1 Pretest and posttest assignment

The p-value is $< .0001$ smaller than α at $.05$. In another word, the RPG worked as an alternative strategy. This result reveals that the ability of students' reading skill strongly related to students' reading strategy.

4.2 Teacher Interview

The interview results aimed to identify the target teacher's opinions on learning English by using RPG. The target English teacher was the one of the English teachers taught in grade 4. During the research, the English teacher helped the researcher to observe the students in the class. Ten questions were presented by the interviewer (I) to the English teacher (ET). The content of interview was recorded and analyzed by using Krueger framework analysis. The researcher interpreted the data based on the descriptive statement of the raw data (Krueger, 1994).

To answer the research question regarding teacher's perceptions of RPG, the findings show that the English teacher had a positive perception that RPG could increase the students' motivation to learn English. The advantage of using RPG was that the students could learn from intriguing games. Moreover, RPG enhanced the students-teacher's interaction during learning time. Furthermore, RPG could be an effective strategy for problem solving in English teaching. It could help the students to concentrate more in learning English. Hence, the teacher could use RPG as a supplementary teaching for one or two meetings. However, the teacher stated that the difficulty of arranging the computer lab schedule, the unexpected technical problems and the time-consuming game-making process, all may hinder the teachers to use RPG in their regular classrooms.

4.3 Classroom Observation

The third research question, "In what way the RPGs, as an alternative strategy, assist the students to improve reading skills?" aimed to investigate the results of teachers' perceptions regarding RPG for teaching English. The data were analyzed according to seven coding criteria which were mentioned before. The analysis was portrayed by explicating the narrative of coding. This current study described the analysis of observation based on the class division: class 4A, class 4B, class 4C and class 4D.

The findings indicated that RPG could help students to be more focused on their assignments. They were engaged in the reading passages and the activities. The RPG also could increase students' motivation to learn English through the games. Students were able to answer the questions correctly and read the passage loudly. The finding also showed that the students were engaged with the peers and the teachers during the learning time.

4.4 Teaching Reading Strategy Questionnaire

The fourth research question, "Can RPG as a supplementary reading for teaching English?" was employed to investigate different perception regarding RPG as an alternative strategy for improving students' reading skill and for teaching English. The data were analyzed based on ten coding criteria such as; student competency, interest, teacher's compliment, teacher's difficulty; the benefit of RPG, the appropriateness program, teaching style, rejection, pause and English teaching process in RPG. The analysis was portrayed by explicating the narrative of coding. This current study described the analysis of Teaching Reading Strategy Questionnaire based on the opinions of 4 teachers.

Interestingly, all the teachers agreed that the benefit of using RPG was to acquire the contextual meaning of new vocabulary words by using the pictures and animations. They described that the virtual animations, dialogue, reading comprehension, the narrator and the questions were the parts of facilitating English learning process. They agreed that RPG could increase the students' motivation and attracted students' attention in learning. All teachers predicted that RPG could help them to prepare the materials by using the dialogue in virtual characters' conversation. Hence, the students would learn English easily. However, All teachers commented that they had a difficulty in designing RPG due to they have not mastered the program yet. Overall, all teachers agreed that RPG could be a supplementary pedagogy for English teaching.

5. Conclusion

According to the findings, four research questions were answered properly. Students' reading competency improved after the intervention of RPG, and the target English teacher had a positive perception regarding RPG. Moreover, RPG enhanced the interaction between teachers and students. Hence, it can be concluded that RPG can be a supplementary English teaching strategy for improving students' reading skill. It can help the students to be more focused on their assignments, and to increase the interaction between students and teachers. Moreover, RPG was a strategy for problem solving in learning English and it could be an alternative strategy in teaching English.

However, this study has a limitation. In the mini workshop, the teachers commented that they had a difficulty in designing RPGs because they have not mastered the program yet. Therefore, it is suggested that if the school does not have enough time to train the teachers, the school could hire programmers to design the games based on the curriculum content.

The second context is that RPG can be employed in private learning or it can be used as supplementary English textbook. It is hoped that the current research could shed light on choosing the alternative strategy to improve students' reading skill. Overall, the findings from this research confirmed the effectiveness of using RPG as an alternative strategy in English reading curriculum and for problem solving.

References

- Cuban, L. (2001). *Oversold and underused: Computers in the classroom*. Cambridge: Harvard University Press.
- Cummins, J. (2000) *Language, power and pedagogy: Bilingual children in the crossfire*. Clevedon: Multilingual Matters
- Davis, F. B. (1944). Fundamental factors of comprehension of reading. *Psychometrika*, 9, 185–197.
- Kamil, M. L., Intrator, S. M., & Kim, H. S. (2000). The effects of other technologies on literacy and literacy learning. In M. L. Kamil & P. B. Mosenthal (Eds.), *Handbook of reading research*, 3, 771–788. Mahwah, NJ: Lawrence
- Krueger, R. A. (1994). *Focus groups: A practical guide for applied research*. Thousand Oaks, CA: Sage Publications.
- Lauder, A. (2008). *The status and function of English in Indonesia: A review of key factors*. Departement of Linguistics, University of Indonesia.
- McKenna, M., Reinking, D., Labbo, L., & Watkins, J. (1996). *The effects of electronic trade books on the decoding growth of beginning readers* (Tech. Rep.). Athens, GA: National Reading Research Center, University of Georgia and University of Maryland.
- Meskill, C., Mossop, J., DiAngelo, S., & Pasquale, R. (2002) Expert and novice teachers talking technology: Percepts, concepts, and misconcepts. *Language Learning & Technology*, 6 (3), 46-67.
- Meyer, A. & Rose, D. H. (1998). *Learning to read in the computer age*. Cambridge, MA: Brookline Books.
- Miller, L., & Olson, J. (1994). Putting the computer in its place: A study of teaching with technology. *Journal of Curriculum Studies*, 26 (1), 121-141.
- Moshell, J. M., Wei, L., Makwana, A. P., McDaniel, R. (2007). Role playing games and language learning. *Technical Report UCF-SFDM-2007.2*
- Rothschild, M. K. (2008). The instructional design of an educational game: Form and function in JUMP. Retrieved from: <http://www.cosmoschaos.info/downloads/Instructional%20Design%20and%20Games.pdf>
- Santoso, T. (2006). The benefits of bilingual education and its applications in Indonesia. *Jurnal Pendidikan Penabur*, 6(Th.V).
- Warschauer, M. (1996). Computer-assisted language learning: An introduction. In S. Fotos (Ed.), *Multimedia language teaching* (pp. 3-20). Tokyo: Logos International.

The Interactive Building Projection on Heritage Based on Game-Based Learning—A Case of “Red Building in National University of Tainan”

Wen-Lin HONG*, Yi-Hsin CHANG, Hen-Yi CHEN & Hao-Chiang Koong LIN
Department of Information and Learning Technology, National University of Tainan, Taiwan
* kuro2357509@gmail.com

Abstract: Although Taiwan has abundant culture of history and heritage, people seldom be interested in learning the cultures of history. We hope to combine the history with digital technology, so we design Processing programs to implement the Building Projection that contains the technology of Projection Blending and Projection Mapping and combine the App to add immediate interaction. Thus, the user can achieve the Game-based Learning via the interactive game. In this research, by taking the Red Building in National University of Tainan as an example, the users can utilize the Mobile Device to interact with Red Building, and carry on through three stages of interactive game; that is, becoming the defender, designer and eyewitness to experience the past history of Red Building. In the interactive game, the people can learn the history and culture; furthermore, it can inspire the concept of heritage protection and increase the identity about local culture of Taiwan in people. In this research, we use Expert Evaluation Method to improve our system and game mechanics based on the opinion of experts to increase the foundation of Game-based Learning. Besides, we use System Usability Scale (SUS) to analyze the usability and satisfaction of the system. The results of the scale showed that the users give a good evaluation about the usability and satisfaction of the system. We expect that the interactive technology can combine with more culture of heritage to enhance people identification of the culture of history. It's aimed to keep the meaningful culture of history forever.

Keywords: Game-based Learning, Building Projection, Projection Mapping, Projection Blending, Mobile Devices

1. Introduction

Tainan is a city with abundant history and culture in Taiwan. There are many heritage that had stayed hundreds of years and left many traces. As now, we can learn the history guided by the narrators or the words. But we are not just learning the history, we can also be the protector of the historical culture of heritage. Although the Building Projection is amazing now, but it seldom interact with the viewer. Therefore, in this research, by taking the Red Building in National University of Tainan as an example, we hope to transfer the amazing Building Projection from one-way article to a two-ways digital art article, so we combine Building Projection with the App for the users to see the process that Red Building be rebuilt and interact with the building by the game. By this way, the users can learn the history and know the importance of heritage protection, also can achieve the Game-Based Learning.

In this research, we use Expert Evaluation Method to improve our systems and make it better. Besides, the server and the Mobile Device should operate in coordination to create immediate interaction on the image of Building Projection. After that, we should make a film that can match the structure of the building. At the end, we use System Usability Scale (SUS) to analyze the usability and satisfaction of the system.

2. Literature Review

Game-Based Learning

Marc Prensky (2001) had proposed the concept of Digital Natives and Digital Immigrants in 2001. Digital natives grew up in the digital world. Their life was surrounded with Internet, television and other digital tools. They are good at using technical products. Digital Immigrants are quite distinct from Digital Natives. They were born in the age without completely information environment, and went through the transition when the typewriters gradually developed into Internet. Prensky (2001) even claimed that the section of the population of Digital Immigrants, which included most teachers, had to adapt themselves to unfamiliar technology for communicating with Digital Natives. The disparity of technological skills and interests between students and educators is easier to generate alienation and disaffection among them. (Sue Bennett, Karl Maton and Lisa Kervin, 2008). How to apply information technology to enhance Digital Native' learning motivation had become a important question to solve. That is why that Game-based Learning had been highly regarded. Game-Based Learning is precisely about integrating computer games into educational contents (Marc Prensky, 2001). It can raise learners' interest in participation, and solve the disadvantage that traditional education can't attract learners into learning (Mark Griffiths, 2002).

Building Projection

Building projection is an amazing projection technique that can project the movie on the irregularly shaped surface and make it fit perfectly on the building surface via Projection Mapping (INTEGRATED VISIONS, 2013). It combines the door and windows of building with the movie to display a stunning effect that change the structure of the building. It is superior to the ordinary projection technology. It allows buildings to move, transform and even communicate with people (Ryan Lum, 2010). Building Projection can give the building a new life, and show fantastic effects to surprise people. Most Building Projection shows visual effects with the movie, but the interaction is insufficient. Therefore, the breakthrough is the applications of interactions. Both the voice interactive Building Projection which can produce structural changes of building via people's sound exhibits in France in 2010 (Laughing Squid, 2011), and NuFormer Company's design: "Mocap Mapping" which merged of video mapping and live motion capture had shocked the field of Building projection(NuFormer Blog, 2013). Motion capturing is also a goal we'll actively achieve.

Mobile Devices and Mobile Learning

Due to the invention of the technology and the wireless networks , the functions of mobile device are more inclusive of everything such as playing online game , browsing on Internet , receiving the e-mail and so on. It makes a new style of learning: Mobile Learning. Quinn (2000) thought that mobile learning is e-learning through mobile devices. Hoppe, Joiner, Milrad, and Sharples (2003) were proposed that mobile learning is the style that using mobile technology and wireless communication for learning. There are at present many mobile devices, for instance, laptops, personal digital assistants (PDA), e-book reader, smartphones, etc. Because smartphones have the characteristics of powerful functions and portability, most mobile devices for mobile learning is taking smartphone in current. Motiwalla (2005) thought that if the application of mobile learning was suitable, it can make up some deficiencies of learning styles or increase its value. It can't show the superiority of mobile learning with only presenting original written materials to the mobile device. History of building is designed into an interactive learning game in this research. We are looking forward to combining multifunctional mobile devices with building projection. So that when learners interact with building by using the mobile device, they can understand the history of rebuilding, and enhance the learners' learning motivation of history and culture.

3. Research Methods

Research Architecture

In order to find the research questions out, we face many technique problems. These problems are about projecting correct scale images on irregularly surface of building, interactions between projection and mobile devices. We set a two-port-two-projection system, including input port and output port. Input port is mobile device port, and output port is server port. The following Figure 1 is shown.

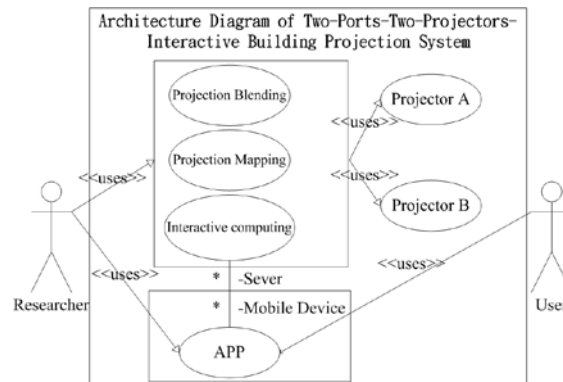


Figure 1. Architecture Diagram of Two-Ports-Two-Projectors-Interactive Building Projection System.

There are three purposes in the server port: Projection Blending, Projection mapping and Interactive computing. Projection Blending should be used when multi-projectors played at the same time. In order to make ranges of Building projection maximum, we overlap the areas of projection. The area of luminance is brighter, so we make their luminance unanimous by using Layer Mask. And Projection mapping is used to project correct scale images on irregularly surface of building. We can't put the projectors high enough so that the angle of projecting will become bigger. So we separate the areas of projection by Mapping. We map every separated areas on correct positions, and they will match with the building. In the end, we finish server with making specially good effect films by using Adobe After Effects and making real-time effects by Processing.

The Application of mobile device port is major tool for user. This research will employ Processing in two respects. Make real-time images about defending building, drawing the wall, etc, and connect mobile device port with server port. We connect mobile device port with server port via oscP5. OscP5 is a library written by Andreas Schlegel for the programming environment processing. It is a network communication protocol put forward by CNMAT(Center for New Music and Audio Technology). We make two ports as input and output. Then, the two ports can transfer instructions and position (which is keyed by the user) to each other. After that we can use the information to generate the display of the building projection, and output it to two projectors port in the end.

Game design

This research chooses Red Building of National University of Tainan for example. Red Building is the national historical building in Taiwan and the historical site for Tainan. Red Building has built since 1922 and now has more than 90 years of history, which there were five times change of building reconstruction. This research shows five reconstructions by "Interactive Building Projection Based on Game-Based Learning ". The game procedure can be divided into three major stages mainly such as Figure 2.

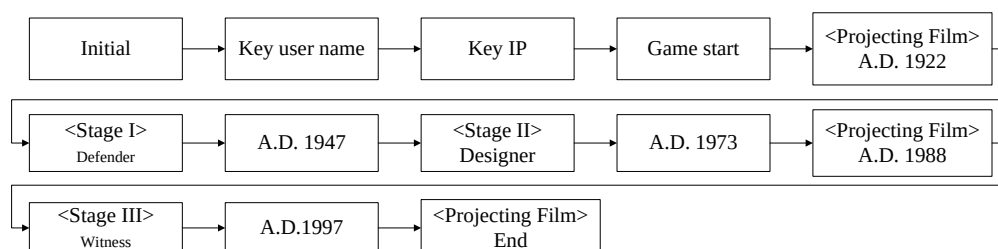


Figure 2. Game design procedure

Before the game starts, the user should key his/her name and IP of server. It projects a starting movie on Red Building after the game starts. Then, it is going to being the first stage game: "Defender". The background of Defender is World War II. The user should prevent people and Red Building attacking by allied forces. The user needs to make protection casings to protect peoples and Red Building by clicking coordinates on mobile devices. If protection is successful, the honor will increase. In this stage, defender symbolizes that people maintain heritages and protect heritages from damage. When time is up, server will compute honor and project it onto Building. The user and audiences will watch honor of user. It will produce the blanket bombing and totally demolish the Red Building in the end.

After the Red Building is totally destroyed, server will broadcast a short film about Red Building rebuilt in 1947 on the projection. And it is going to enter the second stage game: "Designer". The honor from Defender will be changed into Designer's game time. The processes will all show in the Building Projection to make the user and audience understand game rules. The interface of mobile device will be changed into a interface that the user can use tools to design his/her own picture. Tools include painting brush, special-effect, change the color etc. As the following Figure 3 is shown. Designer makes the user have more interactive with the heritage. Different users will have different intentions and ideas so that the Designer makes users create one's own bright memory to Red Building.



Figure 3. Designer



Figure 4. Witness

After the second stage finishes, the server will show that Red Building which is Chinese style building in 1973 and Red Building which is rebuilt in 1988 by broadcasting a film. The film will display the building characteristics of this two years, including green glaze pan tile and golden yellow glaze semicircular tile in 1973 and ceiling and plastic steel doors and windows placed an additional in 1988. Then, enter the final stage game: "Witness". The final stage is easier to the first two stages. The user will daub the mobile device that Red Building which is view today display gradually. The following Figure 4 is shown. The user will witness the history of Red Building through masks. At the end of the game, we will project an ending film that the game end in the integrity.

Prototype evaluation

In order to understand the research value of this research and the system usability about the interactive building projection. We design the prototype to assess System Usability Scale (SUS) and experts evaluation. The prototype is made up of using presentation and mobile device. We explained research contents by presentation and simulating the game procedure by mobile device. It makes experts and testers can clearly understand our research contents.

4. Results

In this research, we collect the opinion of experts from various domains to improve our system and the effects in the process of the interaction by using the Expert Evaluate Method. We achieve the Game-Based Learning by add the elements about the games to make the interaction more interesting. In the game, everyone use different method to protect the heritage and they got the different feedback. Therefore it increases the pleasure of viewer to join the interaction. Furthermore, we achieve the Game-Based Learning by the interactive game that makes more people to learn the history of Red

Building and the meaning of heritage protection. At the end, we invited the viewers to fill the questionnaire that using the System Usability Scale to analyze usability and satisfaction of the system. We will explain the results of Expert Evaluation Method and System Usability Scale.

We invited four experts from various domains and collected their opinions to improve our system. One of them is artist, and others are professors who are good at digital learning technology. As the Table 1, we classify the opinions of experts by various items. According to the opinions of experts, we improve many things and increase different interaction in the game, for example, sliding the screen, increasing the tools and giving the users more feedback. We benefited greatly from the opinions of the experts so that we can make our system better and attractive.

Table 1: The opinions of experts

Item	Opinions
System Design	• The program should control the situation so that can prevent the mistake. • Use the program is more complex than 3D modeling. • Should emphasize main concept-“Heritage Protection”
Interact Design	• More than one user can interact at the same time, different user get different feedback. • Swinging the Mobile Device can make the effect of breaking • Add the Kinect to increase the interaction • Do not limit the interactive effects, it should be immediate,
Interface Design	• Can slide to appear the new building, also let viewer know the history in the process.
Film Design	• The film should be lifelike, it cannot have the aside.
Game Mechanism	• Can play more different kind of the game. • The viewer can keep the memory after interaction. • Changing the game mechanism, let users protect the heritage, can attract more people.

System Usability Scale (SUS) is a subjective feeling scale often adopted in use research. The result of this questionnaire is using the prototype evaluation of 3.3 Research Methods. There are 32 testers. We converted the system use scale to actual scores via formula. The Table 2 is the converted scores of descriptive statistics. The average score is 73.75, the standard deviation is 10.8824, and the median score is 72.5. To use the average score to follow the example of Figure 5., the score is about at the “good” level. It reveals that users have a good evaluation for the usability and acceptability of interactive building projection.

Table 2: Describing statistic of the mark after the System Usability Scale is changed.

Sample number	Average	Median	Standard deviation	Minimum	Maximum
30	73.75	72.5	10.8824	57.5	97.5

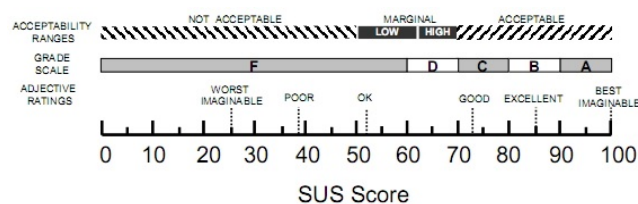


Figure 5. The score of System Usability Scale (Aaron Bangor, Philip Kortum, and James Miller, 2009).

5. Summary and Future

In this times, people seldom cherish the historical culture in Taiwan; moreover, they hardly have the concept of preserving the heritage. Therefore, in this research, we hope to create a new type for viewer to learn the history and know the meaning of heritage by combining the interactive Building Projection with the interactive game. According to the result of Expert Evaluation Method, we add more game mechanism to the interaction so that the users can achieve the Game-Based Learning by playing the interactive game and knowing the concept of heritage protection.

In this research, we use the tablet to interact with the building, in the future, we hope to add the technology of Kinect so that the users can interact with building via their movements. Furthermore, we hope that more than one people can interact with the building at the same time. Thus, it can be more attractive via the mode of Cooperative Learning. In the future, we hope to make use of the Building Projection on various heritages until we have more skillful technique, giving the heritage guide a new style. Thus, it can attract more people to know the historical culture of Taiwan and inherit the culture of the heritage forever.

Acknowledgements

The authors thank the National Science Council of the Republic of China, Taiwan, for financially supporting this research under Contract No. NSC 102CFA0F00028. The anonymous reviewers are appreciated for their valuable comments.

References

- Bangor, A., Kortum, P., & Miller, J. (2009). Determining what individual SUS scores mean: Adding an adjective rating scale. *Journal of usability studies*, 4(3), 114-123.
- Bennett, S., Maton, K., & Kervin, L. (2008). The 'digital natives' debate: A critical review of the evidence. *British journal of educational technology*, 39(5), 775-786.
- EDW Lynch. (2011). Video Projection Mapping Creates Illusion of Dancing, Singing Building [Web blog]. Retrieved Sep 25, 2013 from <http://laughingsquid.com/video-projection-mapping-creates-illusion-of-dancing-singing-building/>
- Griffiths, M. (2002). The educational benefits of videogames. *Education and Health*, 20(3), 47-51.
- Hoppe, H. U., Joiner, R., Milrad, M., & Sharples, M. (2003). Guest editorial: Wireless and mobile technologies in education. *Journal of computer assisted Learning*, 19(3), 255-259.
- Integrated Visions. (n.d.). Projection Mapping in Art, Design, and Production [Web blog]. Retrieved Sep 25, 2013 from <http://videomapping.tumblr.com/>
- Motiwalla, L. F. (2007). Mobile learning: A framework and evaluation. *Computers & Education*, 49(3), 581-596.
- NuFormer Blog. (n.d.). 2012 to 2013-Looking back and forward [Web blog]. Retrieved Sep 25, 2013 from <http://www.nuformer.com/blog/page/2/?tag=2012>
- Prensky, M. (2003). Digital game-based learning. *Computers in Entertainment (CIE)*, 1(1), 21-21.
- Prensky, M. (2012). Digital natives, digital immigrants. *On the Horizon*. MCB University Press, 1.
- Quinn, C. (2000). mLearning: mobile, wireless, in-your-pocket learning. *LiNE Zine*, 2006.
- Ryan Lum (2010). 12 Must see Guerrilla 3D Projection Mapping Examples. Retrieved Sep 25, 2013 from Creative Guerrilla Marketing website: <http://www.creativeguerrillamarketing.com/guerrilla-marketing/12-must-see-guerrilla-3d-projection-mapping-examples/>

The Evaluation Framework for the Group Development Process of Adventure Education Game

Chang-Hsin LIN, Ju-Ling SHIH*, & Yu-Jen HSU

Department of Information and Learning Technology

National University of Taiwan, Taiwan

*juling@mail.nutn.edu.tw

Abstract: It has been implemented for a long time about the development of physical adventure education activities. However, there were no papers to discuss the application in technology. This study uses Tuckman stage of team development to develop a digital games course of adventure education and chooses suitable process evaluative tools. Researchers can investigate the changes of members' interactive behaviors and group development with the tools. Finally, this study will use questionnaires to explore the learning effectiveness of adventure education and the satisfaction of the digital games course.

Keywords: group dynamics, adventure education, Digital Game-based Counseling,

1. Introduction

In the last several decades, adventure education was implemented in the physical form. Students have been grouped up and experienced the activities in the wild for a few days. Members experience their group activities from being strangers to partners. They went through the courses and have face-to-face contacts with members. Goals for the activities were learned in the reflection sessions after each activity. Students could use the lessons learned to situations in their lives. However, few studies have provided insights of using digital games for adventure education.

With the advance of science and technology, many teenagers are addicted to digital games, which are not intimate with the nature and are distant from the crowd. Traditional adventure education is seldom their leisure or learning options. Conversely, teenagers are more apt to present themselves in the virtual world, such as their ideas, emotions, and real personalities. If digital games become the medium for adventure education, do teenagers can establish the relationship with more people and communicate more easily? Are the learning effects same or better than the physical form? How to be changed the students' interaction?

This study presents the design of an adventure education course based on digital games following the principles described in the Tuckman stages of team development model. Qualitative data are collected to observe the processes of the team developments, to investigate the changes of the teams and members, and their problem-solving processes. The guidance teacher would lead students to review their gaming processes with the gaming records. Facilitators can understand the problems and find the right way to solve it on explicit gaming roles and integral gaming records. Members can reflect and internalize lessons learned in the reflections. The games have been made by the game engine – Unity3D. Combine adventure education and digital gaming elements, students not only can enjoy the fun of the games, but also can learn the connotation of adventure education. It is our ultimate goal to combine education with recreation.

2. Literature review

2.1 Adventure Education

Adventure education is a series of risky and challenged activities that experienced by students. By participating the activities, students think and internalized the connotation of adventure education through the personal experience of the activities and group reflections after the activities by the

guidance. Ideally, the students also apply what they learned in the activities to situations in their life. Traditionally, students passively learn in teachers' lectures without much interaction. On the other hand, teachers play the guidance role in adventure education. Students take initiations and learn by doing. As students internalize the knowledge in the learning process, they increase interests to participate the learning process and put conceptual contents into practice so that learning effectiveness can be improved.

The courses of adventure education were originally long and extensive. It takes days or even months to finish. Glass and Myer (2001) used the essences of adventure education to design small-size courses of adventure education which only takes a few hours. They thought the learning effectiveness of adventure education should not only be analyzed with questionnaires. Research should add observations and interviews to understand students' learning effectiveness. They thought the individual state of mind would affect students' behaviors in groups. Therefore, they observed students' performance in the reflection session from the individual psychology aspect. For several years, studies in adventure education have been based on thematic activities. Baldwin, Persing, and Magnuson (2004) as well as Brown (2006) pointed out that those studies have over-focused on the difference between pre-test and post-test. Those studies ignore the change of students' learning styles and behaviors in the process. Zmudy, Curtner-Smith and Steffe (2009) offered a detailed account of using qualitative research method by adding observations and interviews to investigate the change of students' self-concept, peer relationships, and interpersonal skills during the process.

More recently, the course design of adventure education has been a fixed process in Taiwan and abroad. The course design was based on Tuckman and Jensen's (1977) stages of team development model. The five stages were combined with the activities of adventure education. According to the characteristics of every stage, suitable activities were chosen to be used in the adventure education courses. Through the activities, groups were developed to be high-performance teams. Nevertheless, there were still only few papers that explore the details in the process. Thus, this research tries to present a detailed analysis to the learning process.

As the technology advances, network became a part of people's life in recent years. Teenagers are addicted to the online games. Physical activities are less effective and attractive comparing to the digital ones. It is also the goal of this research to apply digital technologies in the course without losing the effects of adventure education.

2.2 Group dynamics

People get together without interaction. It does not mean a group. For several decades, many people have taken many different explains about group. In 1991, Johnson and Johnson's (1987) conception about group is value for studies from now on. They thought the group mainly consisted of two or more individuals which conform to some conditions: (1) Interact with each other; (2) Rely on each other; (3) Sense of belonging to group and each individual is recognized by other members; (4) Follow group rules; (5) Cross influence to each other; (6) Looking for group benefits and rewards; (7) Achieve common goals. As group is working, group needs to support by energy. One of the most widely cited theories of group dynamics has come from Kurt Lewin in 1930s. Though the following development of the theory diverges to different directions, all in all, group dynamic investigates and describes the members' behavior changes in the group or between groups.

One analysis method about group interactions is Bales' interaction process analysis (IPA) which is especially suitable to analyze problem-solving groups. IPA considers interactive behaviors from two dimensions including task dimension and socio-emotional dimension. The two dimensions are opposite to each other. According to Bales' research, two different behaviors can make a balance along with the group development. For the typical problem-solving groups, the ratio of task dimension and socio-emotional dimension behaviors approaches 2:1 (Bales, 1950). It can be seen that task dimension behaviors are mostly used to achieve group goals, and socio-emotional dimension behaviors are used to allow success group develop. Members' interactions can be easily recorded in detail by IPA. Behaviors are considered to be data which can be observed, synthesized, and analyzed. From the recorded data, group development problems can be identified and solved so that group efficacy can be raised. IPA was widely used in the recent years. Studies range from counseling, group efficacy, and parent-child relationships that focused observing the physical activities. Some studies investigate about the use of technology to help researchers record web and game dialogs. Nam, Lyons, Hwang, Kim, and Severino (2009) as well as Messina (2010) have used computer-assisted tools for recording

observations. But those researchers all pointed out one thing that communication is easy to record and observe with computers, but group interactions are less effective than face-to-face communication. Soong (1989) thought that group process is an interactive process, and interaction is the core condition in groups. Members have to interact with each other to increase group effectiveness, and so does it in the adventure education courses. In the related studies of adventure education, there are some studies using IPA to observe members' interactive process of outdoor activities. However, there is few to investigate members' interactions in the digital games especially for adventure education.

Hill interaction matrix (HIM), on the other hand, is also an interactive analysis method. It is used on the developing groups and treatment groups (Hill, 1977). It synthesizes group interaction patterns with a multi-dimensional matrix. HIM mainly records group members' interactions by work and content vectors. It has four advantages: (1) High surface efficacy; (2) Cover all spoken languages that are meaningful statements; (3) Easy to teach and learn; (4) Record the communication process instead of making generalization of structure and behaviors (Pan, 1999). Content vector includes questions concerning topic, group, personal, and relationship, within which general interests, group, personal, inter-relational problems are included. Work vector includes responsive, conventional, assertive, speculative, and confrontational oral presentation types. Through HIM, researchers can identify treatable behaviors. Most researchers use HIM on counseling and medical arena. Because the analysis process of HIM is too complex, many researchers developed scales to expedite the process. So far, HIM has not been seen to be used in the group development process analysis in adventure education.

Sociometry is designed by Jacob Levy Moreno (1934) which is mainly used to observe the transformation of group structure. The method is to assess the fondness of group members to others. Through interviews and questionnaires, Sociometry can show the hierarchical relationships between members graphically, such as exclusiveness, popularity, attractions, influence, and so on. When group structures change, sociogram shows the changes. Sociometry was widely used in different fields. It was first used in educational counseling such as therapy, diagnosis, and evaluation. Later, it was used on enterprise, military, industry fields, and so on. The topics include leadership style, work assignments, group morale, and group organization.

2.3 The activity process of adventure education

Interactive analysis is used in both physical and virtual groups. The groups can be divided into two types: (1) Task groups are those to achieve goals and missions. ; (2) Developing and treatment groups are those focus on individual or group treatments. Internal changes are observed for these groups.

The activities of adventure education can be divided into three stages (Henton, 1996): (1) Brief: Before activities begin, facilitators have to talk to students about activity rules, goals, situations, and restriction. It is to raise students' attention rules and goals. (2) Activity: Students start to experience activities. Facilitators play the role of assistants who help students finish the courses. They are not lecturers in class. (3) Debrief: Facilitators help the students to understand the meanings of the activities through reflections. Students internalize the connotations of adventure education. When in the activities, the group functions as a task group. The goal is problem-solving and mission completion. When in debrief, the group functions as the developing and treatment group. Therefore, in order to effectively observe and analyze the adventure education course with digital games, different analysis methods and tools are needed.

3. Research Methods

This study mainly relies on qualitative research method supplemented by questionnaires. Research processes have three steps:

Design: This study's experiment is based on the theory of adventure education. Researchers choose suitable interactive analysis in group dynamic. Interaction process analysis (IPA) can be used in Activity; Hill interaction matrix (HIM) can be used in Debrief. Then, researchers begin to develop the adventure education course with digital games that are made up of activities in accordance to the Tuckman stages of team development model.

Execution: Based on Interpersonal Behavior Survey (IBS) (Mauger & Adkinson, 1993), participants are divided into three groups: High social interaction group, Low social interaction group, and mix. Then, participants fill out the pre-questionnaire to understand their acknowledgements to the

adventure education course and their expectations about the digital games. During the course, observation will be conducted (1) Unstructured observation. Researchers record the interactive process with the interaction analysis chart. (2) Participant observation. Facilitators are the observers. Researchers participate the course to have an inside look of the group situation. At the end of every activity, the participants fill out the questionnaire of sociometry. The group development pattern was shown in the short-term sociogram. Other than that, the course will be recorded entirely with video. After the course, the participants will fill out the post-questionnaire. Facilitators will interview some groups and the individuals which are special cases in the course.

Analysis and discussion: Data analyses have two parts: (1) pre-and post-questionnaire comparison: From the pre- and post-questionnaire comparison, researchers investigate the learning effectiveness of the adventure education course, and participants' satisfaction level to the digital games. (2) Process analysis: Researchers compares the observation results, short-term sociograms, videos, and facilitators' interviews to visualize the changes of group interactive process which shows the transformation of group structures. Finally, the study will discuss the results, problems, and corresponding suggestions that are to be improved.

4. The digital games based adventure education course

The games in this study are for adventure education which require highly realistic. Therefore, Unity3D game engine is chosen to develop the games. Besides simulation, this game engine has high performances in particle effects and physical collision. Players can be immersed as if they are in the real scene. Unity3D also supports cross-platform publication such as PC, IOS, Android, XBOX360, Wii, and Web. Since the physical activities vary, the digital games of the adventure education course have to be presented on and with different platforms to serve the needs. It saves time to use Unity3D to make cross-platform games.

Tuckman (1977) thought the development of groups go through stages and in order, therefore, the theory describe the process in five stages. However, members' negative behaviors in the storming stage such as misunderstanding and bad communication can hinder group development. In this condition, groups need to be high-performance groups to move forward to the next stage. The individuals and groups situations for each stage are described in Table 1.

Table 1: Situations of group development in Tuckman's five stages

	Individual situations	Group interaction situations
Forming	1. Explore, feel strange to everything. 2. Both individual and group goals are not clear. 3. Look for his position in the group.	1. All members are not familiar with each other. 2. Finish personal works without group work.
Storming	1. Look for the individual goals 2. Have personal opinions, dealing with works from their own angles. 3. Have influence in group.	1. Form small groups. 2. Groups have abilities to divide the works to each member, and can complete simple missions.
Norming	1. Understand group goals. Individuals are team-oriented. 2. Accept others' opinions and views, and make adjustments. 3. Personal motivation. Members take roles in groups.	1. Cooperation. Members finish all missions successfully. 2. Groups work on the same rhythm. Understand personal roles and values.
Performing	1. Identify with group goals. Have personal ideals. 2. Look for further growths and changes. 3. Help partners to grow from each other.	1. Have great interactions and work skills. 2. Have great group climate. Cover and support each others.
Adjourning	1. Share self-reflections and experiences. 2. Produce common memories in the development process. 3. Say goodbye. Start next cycle.	1. The cycle ends. Review and share the process of group development, common experiences, and memories.

Researchers refer to “Experiential education- learning from 150 games” (Hsieh, Wang, & Chuang, 2008) and “Experiential education: theory and practice” (Kuo, Liao, & Shih, 2009) to identify appropriate activities of adventure education for developing the digital games. The course works with groups of five people. The course designs with a series of digital games based on Tuckman’s team development model. The five group development stages are explained as follows.

Forming: Members meet each other for the first time. They feel strange about everything. In this stage, warm-up activities are chosen to let members communicate, share, and give opinions frequently so the members can be familiar with each other. Members build the initial group relationship. The goal of the first stage adventure education activity are breaking fixed conception, creating of group relationship, and making reflection. The game digitized for this stage is Polar Bear and Hole (Figure 1). The game starts with a story which provides hints for the task. The facilitator throw dices three times for giving hints. Then the members discuss, observe, and induce for correct answers following the logistics of the story.

Storming: This stage contains activities which prevent oral communications between members. All members have to work together to complete the tasks. In this stage, members try to discuss the group problems with their internal dialogues. Their personal weaknesses and group problems are improved by themselves. Groups can be high-performance teams. The goals of the adventure education activities in this stage are problem-solving, cooperation, trust, breaking fixed conception, communication, respect, and reflection. The games which are used in this stage are Cooperative Puzzle (Figure 2) and Chessboard Maze (Figure 3). In Cooperative Puzzle, everyone gets three puzzle pieces out of total of fifteen puzzle pieces. All five members in the group need to work together to put up five equal-size squares with puzzle pieces. Members can exchange puzzles with others without discussion. They can only give out puzzle pieces, but cannot ask for them. The goal of the game is to make members realize their roles in the group, and pay attention to others’ needs. The game Chessboard Maze is played by only one person at a time. There is only one path to pass the 9x5 chessboard which is full of landmines. When the player goes through the wrong path, he has to start over again. Every failure leads to point deduction. The group has to change player whenever the landmines is intrigued. The goal of the game is to build the trust between members, and to generate gaming strategies together through trial-and-error, members’ experience, break fixed conceptions, and challenge obstacles.

Norming: After storming, members start re-thinking about relationships between individuals in the groups. Through communications, members start to trust each other. Members achieve group goals more rapidly and create greater effectiveness. The goals of the adventure education activities are leadership, communication, cooperation, and reflection. The game used in this stage is Moon Ball (Figure 4). Members pat the ball cooperatively to keep the ball in the air as long as they can. One person cannot pat the ball twice continuously. The goal of the game is to train members to use strategies to cooperate with each other.

Performing: After going through the difficulties and frustrations in the previous activities, members now have skilled cooperative strategies and are in great interactions. The goals of the adventure education activities in this stage are leadership, trust, communication, cooperation, and reflection. The game used in this stage is Group Balance (Figure 5). The game requires three people to play. One member keep balance of the board and the other two members push the balance board upward on the two sides until reach the target height. The purpose of the activity is to increase members’ reliance, cooperation strategies, and face the challenges.

Adjourning: Group development process comes to the end. Members share their experiences and encouragement to each other. Groups start to have existing members to leave, and new members to join. Groups start a new cycle. The goals of the adventure education activities are leadership, trust, communication, cooperation, and reflection. The game used in this stage is Cycle Maze (Figure 6). Members first read a maze map and try to memorize it. Then, they get fourteen pieces of boards to construct the maze as they memorized. The purpose of the activity is to train members to solve problems and communicate. It strengthens their group concepts and identifies their roles.



Figure 1. Polar Bear and Hole

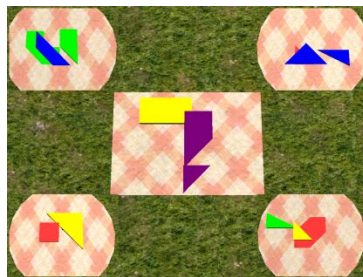


Figure 2. Cooperative Puzzle

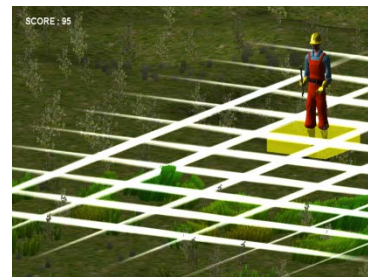


Figure 3. Chessboard Maze



Figure 4. Moon Ball

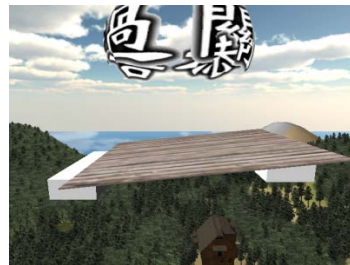


Figure 5. Group Balance

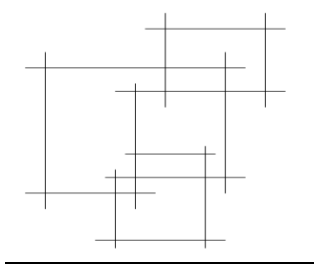


Figure 6. Cycle Maze

5. The evaluation framework for group development

This paper adopts some physical activities which are based on theory. Physical activities base on Tuckman's stages of team development model. Unity3D is used to develop the adventure education course with digital games. In every stage, researchers use suitable interactive analysis method to observe and record. Interaction process analysis (IPA) will be used in Activities; Hill interaction matrix (HIM) will be used in Debrief. Finally, researchers use sociogram to make the graphs which can show the change of group structure. The processes of the reflection and members' interaction in course are recorded by interactive analysis (Figure 7).

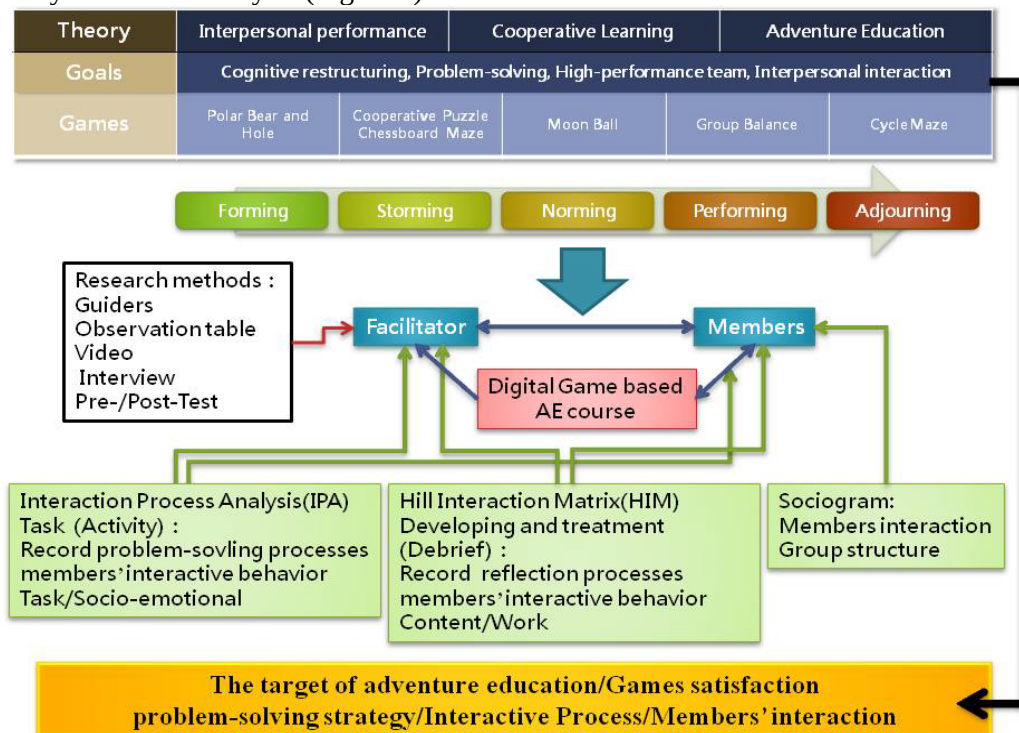


Figure 7. Research structure

5.1 Interaction Process Analysis(IPA)

According to Bales' (1950) interaction process analysis, groups have to solve problems in two dimensions. 1. Task dimension: The contents of discussion are the situations which members have to solve, suggest, ask, order, and guide. Task-oriented interactions are classified in the areas. 2.

Socio-emotional dimension: The contents of discussions are the situations which concern the coordination, opinions, acceptances, and conflicts in members. Socio-oriented interactions are classified in the areas. In Table 2, during the group development process, all interactions can be recorded. Through the data which are recorded by IPA, the group development problems can be identified and resolved.

Table 2: Bales' interaction process analysis (Bales, 1950).

Functional dimension		Content categories	Code
Socio-emotional	Positive reactions	Shows solidarity, raises other's status, gives help and rewards.	F
		Shows tension release, jokes, laughs, shows satisfaction	E
		Agrees, shows passive acceptance, understands, concurs and plies.	D
	Negative reactions	Disagrees, shows passive rejection, formality, with olds help.	D
		Shows tension, asks for help, with raw out of field.	E
		Shows antagonism, deflates other's status, defends or asserts self.	F
Task	Attempted answers	Gives opinion, evaluation, analysis, expresses feeling and wish.	C
		Gives suggestion, direction, implying autonomy for other.	B
		Gives task orientation, information, repeats, clarifies and confirms.	A
	Questions	Asks for orientation, information, repetition or confirmation.	A
		Asks for opinion, evaluation, analysis and expression of feeling.	B
		Asks for suggestion, direction and possible ways of action.	C
Code	A: Problem of orientation. D: Problem of decision. B: Problem of evaluation. E: Problem of tension-management. C: Problem of control. F: Problem of integration.		

5.2 Hill's Interaction Matrix(HIM)

Hill interaction matrix is divided into two vectors: Content and Work. The analysis is used on investigating the developing groups and treatment groups. This analysis is based on the contents in group interactive process instead of the tasks (Hill, 1977).

Content vector reviews the dialogue of group interactions. It includes four aspects. 1. Topic: It includes only the discussion content but nothing about the group or members. 2. Group: Anything about group development, such as activity implementation, leadership style, group work strategies. 3. Personal: Anything about group members. It focuses on behaviors of individual members. 4. Relationship: It discusses members' interactive situations or relationships between members and group.

Work vector reviews the situations of group works. It includes five aspects. 1. Responsive: The interaction is generated by facilitators. Members only give short answers and show reactions. It is mainly designed for members who do not have social interactions or responses. 2. Conventional: The interaction includes greetings and chats. It has no influence to groups. It provides basic group functions. 3. Assertive: Members talk about themselves. It is about the interaction of protestation and refusal. The interaction is mainly argument, hatred, or malevolence. 4. Speculative: Members handle group situations with rationality during discussions. Through rational discussion, personal observation and comprehension about situations are improved. 5. Confrontative: The interaction is about group leaders who face problems they do not want to face. The interaction is normally risky and tensional.

5.3 Sociogram

Sociogram is a way which uses graphs to display members' interpersonal relationships in the particular situations. The graph uses geometrics, names or codes to represent members. According to the past research, round shape represents females, and triangles represent males. Incomplete shapes or colored figures represent member absence. The graph has three layers. Members who are identified the most times are placed at the center of the sociogram. Members who are identified the least times are placed at the edge of the sociogram. Arrows are used to show members who are identified by others. Double headed arrows are used to show members who identify each other. Dashed-line arrows are used to show members who are rejected by others. The group structure can thus be observed and presented with sociogram.

During the course, tools are used to analyze the process. 1. Video: the whole process is recorded on video which will be coded and analyzed afterwards. 2. Unstructured observation: Researchers use observation sheet designed with the interaction analysis model to record members' interactions in the process. 3. Participant observation: Facilitators are the leaders of the course. They observe groups from the internal view of the group. 4. Interview: Through the interviews, researchers can perceive the group changes and interactions more in-depth. 5. Sociogram: After every Activity and Debrief, members fill the sociogram questionnaires. Researchers can observe the change of group structures. 6. Interaction process analysis: The interactions which record on the video are systematically analyzed by sentence syntactic. The interactive behaviors in Activity can be recorded completely. 7. Hill interaction matrix: Same as interaction process analysis. The interactive behaviors in Debrief can be recorded completely.

6. Conclusion

The digital games developed in this study are different from those commercial games. They are educational games. The games have educational goals but also interesting. In this research, researchers implement digital games into adventure education course which attract teenagers. The course is designed with Tuckman's stages of team development mode. The results of this research expect group members to learn the connotations of adventure education. Therefore, researchers choose interactive analysis to design the evaluation framework so that the change of group developments can be recorded and presented. It can generalize the arrangements about groups and the change of group structure, members' interactions, and social skills.

Acknowledgements

This study is supported in part by the National Science Council of the Republic of China, under NSC 101-2511-S-024 -009 -MY3.

References

- Baldwin, C., Persing, J. & Magnuson, D. (2004). The role of theory, research, and evaluation in adventure education. *Journal of Experiential Education*, 26(3), 167-183.
- Bales, R. F. (1950). *Interaction Process Analysis*. Chicago: University of Chicago Press, 1976.
- Brown, M. (2006). Adventure education and physical education. In D. Kirk, D. Macdonald, & M. O'Sullivan (Eds.), *The Handbook of Physical Education* (pp. 685-702). London, England: Sage Publications Ltd.
- Gass, M. A. (1993). *Adventure Therapy: Therapeutic applications of adventure programming*. Dubuque Iowa: Kendall/Hunt.
- Glass, J. S., & Myers, J. E. (2001). Combining the old and the new to help adolescents: Individual psychology and adventure based counseling. *Journal of Mental Health Counseling*, 23(2), 101-114.
- Henton, M. (1996). *Adventure in the classroom*. Dubuque Iowa: Kendall/Hunt.
- Hill, W. E. (1977). The Hill Interaction Matrix. *Small group behavior*, 8(3), 251-259.
- Hsieh, C. M., Wang, J. Y., Chuang, H. W. (2008). *Experiential education-learning from 150 games*. Taiwan, Taoyuan: AAEE
- Johnson, D. W. & Johnson, F. P. (1987). *Joining Together Group Theory and Group Skills*. Prentice-Hall International, Inc
- Kuo, T. Y., Laio, S. H., Shih, H. Y. (2009). *Experiential education: theory and practice*. Taiwan, Taichung: Far Du
- Mauger, P. A., & Adkinson, D. R. (1993). *Interpersonal Behavior Survey manual*. Los Angeles, CA. Western Psychological Services, Inc.
- Moreno, J. (1934). *Who Shall Survive?* New York: Beacon Press.
- Nama, C. S., Lyons, J. B., Hwang, H. S., & Kim, S. (2009). The process of team communication in multi-cultural contexts: An empirical study using Bales' interaction process analysis (IPA). *International Journal of Industrial Ergonomics*, 39(5), 711-782.
- Pan, J. D. (1999). *Group dynamics*. Taiwan, Taipei: Psychological.
- Severino, S. & Messina, R. (2010). Analysis of similarities and differences between on-line and face-to-face learning group dynamics. *World Journal on Education Technology*, 2(2), 124-141.
- Soong, J. J. (1989). *Group dynamics*. Taiwan, Taipei: Wu-Nan Culture Enterprise.
- Tuckman, B., & Jensen, M. (1977). Stages of small group development revisited. *Group and Organizational Studies*, 2(0), 419-427.
- Zmudy, M. H., Curtner-Smith, M. D., & Steffen, J. (2009). Student participation styles in adventure education. *Sport, Education, and Society*, 14(4), 465-480

The Instructional Application of Augmented Reality in Local History Pervasive Game

Jyun-Fong GUO, Ju-Ling SHIH*

*Department of Information and Learning Technology,
National University of Tainan, Taiwan*

**juling@mail.nutn.edu.tw*

Abstract: Pervasive game is a new type of mobile learning, which adds game mechanism into the traditional mobile learning. It increases the interactions of the players with both the learning environment and mobile technology. In this research, Tainan historical monuments are used to be the activity sites of the game. Markerless augmented reality and social community website are used to sustain gaming collaboration and learning motivation. Pre and post tests, system logs, interviews, and questionnaires are analyzed to investigate the influence and effectiveness of pervasive game in learning Tainan culture.

Keywords: Pervasive game, Augmented Reality, Collaborative Learning, Mobile Learning, Social Community Website

1. Introduction

There is a great deal of research work on pervasive game in the past decade. Barkhuus et al. (2005) designed “Treasure” to make player collect or snatch coins to earn game points. According to players’ game experience, they investigated the influence to game strategy and game identification. Benford et al. (2005) made players play games such as lion hunting on the virtual savannah, and investigated their interaction and cooperation. Bell et al. (2006) designed “Feeding Yoshi”, a game last for a week in three cities, to reveal the impact and change of players during the procedure.

The term “pervasive game” is popularly considered to be an extension of mobile learning game which emphasizes more on the creation, use, and manipulation of the learning content. Learning content used for mobile learning is mostly pre-designed; whereas, in pervasive game, it requires users to interact with the learning content or retrieve more learning materials both in the real world and the virtual world. Participants can reach various explanations to the learning content since everyone has different perspectives. With the addition of game mechanism, it is more interesting and intriguing than the current practices of mobile learning.

Until recently, few studies have provided microanalyses of pervasive game on local history. In this research, a role play historical game about Tainan monuments is designed by applying principles described in the literature review. Players interact with historical spots to explore the events happened in the past and search for the connections between the events. In this paper, we re-examine the notion of pervasive game and explore the implementation of augmented reality (AR) technology into the local history learning. Smart phones were used as supplement devices in which hints to the investigation are provided with AR. Players’ learning condition, gaming strategy, and teamwork styles would be analyzed by behavioral observations and questionnaires. The goal is to encourage students to have self-development and self-directed learning.

2. Literature Review

2.1 Mobile Game

The improvement of mobile technology is not only driving mobile-commerce, but also coming up with mobile game. Okazaki, Skapa, and Grande (2008) said that the attraction of mobile game to players is convenience. Game can be played anytime and anywhere. For the past few years, many research presented positive results in all aspects in mobile game, especially on education. For instance, Schwabe

and Goth (2005) grouped students in the mobile game. Different teams were assigned different missions and related geographical locations. Students used Geographic Positioning System (GPS) to complete missions, and then sent answers back to the server by mobile devices. The fastest team won the game. The type of mobile game-based learning is usually called geocaching. Huizenga, Admiraal, Akkerman, and Dam (2009) thought that educational mobile game should integrate situated and active learning. They divided students into mobile game team and traditional team to learn the culture of Amsterdam in Middle Ages. Learning achievement showed that game team is much higher than the traditional one.

2.2 Pervasive game and Design Elements

Pervasive game (PG) is a mobile game combining with physical environment and virtual scenarios. Walther (2005) stated that pervasive game establishes a real and virtual situation for players to play by means of software information system, mobile devices, real objects in the environment, and other assistances. Players are typically equipped with handheld or mobile devices. Wifi or 3G connections are common technologies used for the players to communicate with the virtual environment. To be more precise, location tracking and orientation sensors are usually based on GPS. AR is also used to increase the gamification of gameplay. Laine, Sedano, Joy, and Sutinen (2010) commented that PG is an extension of M-learning. The interaction between the player and environment is the key point. Another annotation about PG was raised by Montola (2011). He stated that “magic circle of play” created by online game is an invisible fence keeping game from real life. Players are also separated. However, PG breaks the circle and bridges real and virtual environment to surge more interaction.

In recent years, many researchers have different thoughts about pervasive game design elements. Walther (2005) offered a constructional framework called “four axes of PG”, which includes: 1) Distribution, refers to the gaming information which can widely and effectively distribute through network; 2) Mobility, refers to user mobility, computing mobility, network mobility, and context-aware and cross platform services.; 3) Persistence, refers to total availability all along; and 4) Transmediality, refers to a media circle that multi-link the world of virtual social networks. Upon the constructional framework, he further introduced three critical units of PG: 1) Game rules: All games must be rule-based and clear defined; 2) Game entities: Abstract class of an object that can be moved and drawn over a game map; it can further shape into three categories, game object, human agent, and physical object; 3) Game mechanics: An input-output engine that monitoring and modifying the physical and virtual linkage to ensure a fluent game flow.

Gentes, Guyot-Mbodji, and Demeure (2010) recognized local culture to be a part of PG, especially Instructional Pervasive Game (IPG). For a cultural-rich PG, they suggested three key features to be included. They are: 1) Collaborative contents: The contents should be designed by people with qualified knowledge or actually living on the premises, therefore, scholars, neighbors, and respectable alike are all contributors of the content; 2) Team exploration: The gameplay either relies on solitary errands or on collective sharing, strategies can be more “group oriented”; 3) Cultural narrative: unlike traditional computer games which always open with a virtual scenario, PG’s are based on urban-cultural representations. There is always first narrative that sufficiently describes the culture of the city therefore game players are able to have a clear idea of the fashionable places, the living or working areas, and the cultural spots.

2.3 Collaborative Learning in Pervasive Game

As mentioned above, Gentes, Guyot-Mbodji, and Demeure (2010) particularly pointed out that recognition of local culture must accompany with co-create content and team exploration. It also strengthened the importance of cooperation learning in pervasive game. Generally speaking, cooperation learning is considered to be an educational strategy, which encourages team member to help, rely on, and share learning resources with each other. Beside reaching the team goal, players can also improve personal learning effectiveness and positive interpersonal relationship (Pragnell, Roselli & Rossano, 2006).

Dyson, Griffin, and Hastie (2004) pointed out that integrating cooperative learning mechanism into games can enhance students to finish the missions more effectively. Huang, Shih, and Lai (2011) also indicated that group competitions can increase learning motivations and working efficiencies since

group competition is the dynamic of cooperation. Edwards (2003) had similar thought that teamwork and competition are the key elements of game, and so as the use of cooperative learning strategies. To this research, game development will take cooperative learning and competition as the major learning strategies.

2.4 The application of Augmented Reality in Pervasive Game

Augmented Reality (AR), also known as Extended Reality, is a computer graphics interactive technology originating from Virtual Reality (VR). Azuma (1997) believed the interactive technology can apply to military, medicine, industrial design, maintenance, commercial activity, learning, and entertainment. To pervasive games or mobile edutainment applications, AR seems to be essential. For instance, Cheok et al. (2002) brought classical arcade game “Pacman” into the real world which is called “Human Pacman” (Figure 1). Players collected cookies made by AR and avoided to be caught by the ghosts. Ghosts in the game are enacted by other players so it is also a multiplayer game. The application of AR in ARQuake (Piekarski & Thomas, 2002) and Treasure (Barkhuus et al., 2005) were used for the players to collect objects. Ballagas, Kuntze, and Walz (2008) designed REXplorer as a historical exploration guide for tourists in Regensburg. Tourists visited landmarks and find the virtual magical spirits and treasures using detectors on their way. Herbst, Braun, McCall, and Broll (2008) presented an interactive time travel game, TimeWarp, which guides the users to explore historic buildings with a AR virtual tour guide (Figure 2).

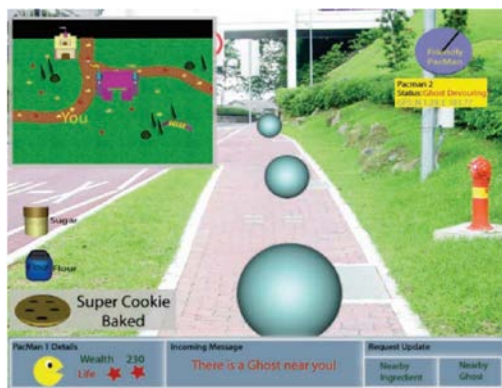


Figure 1. Human Pacman first-person perspective.



Figure 2. TimeWarp virtual tour guide.

Based on the experiences of previous studies, the application of AR in this research adopts markerless AR to make the overall activity more intuitive and natural. Gaming content includes story clues, mission hints, and event keys. Content are presented in the way of websites, animations, or images.

3. Research Methods

Research Process is divided into three phases (Figure 3). The first phase is game design and development stage which maps out the game structure (Figure 4). The research is designed based on the research purposes, PG definitions, and GNS game theory. Game script is designed with Tainan historical events which happened in period of Koxinga and also some folklore stories to increase the fun. The activity space is the historical monuments including Five Concubines Temple, Tainan Grand Matsu Temple, and Tainan Confucius Temple. AR presentations on the players' mobile phones can increase players' gaming motivation and interest. With the instructional pervasive game design, players can have more interactions with the environment.

Social network service, Facebook, is used in the game as a communication platform which can allow players interact with each other. It is not only a communication bridge to players, but also a terminal to researchers (Figure 5). Players' gaming conditions can be monitored. In the experimental

phase, college students are invited as the research subjects. Smart phones are used as the mobile learning tools which are equipped with wireless Internet connections. The phones are installed with ARUSMA and Facebook apps to read AR and to communicate. Before the game, players are divided into groups and Facebook group spaces are installed for interactions. Then, pre-test about the history are conducted to know players' prior knowledge.

In the gaming process, all interactions are recorded as the behavior observations (Figure 6). After the game, historical knowledge post-test are conducted. At the same time, game satisfactions questionnaire and focus group interviews are done to evaluate the learning effectiveness. Behavior observations and interactive course records are used for cross-analysis of the evaluations at the end.

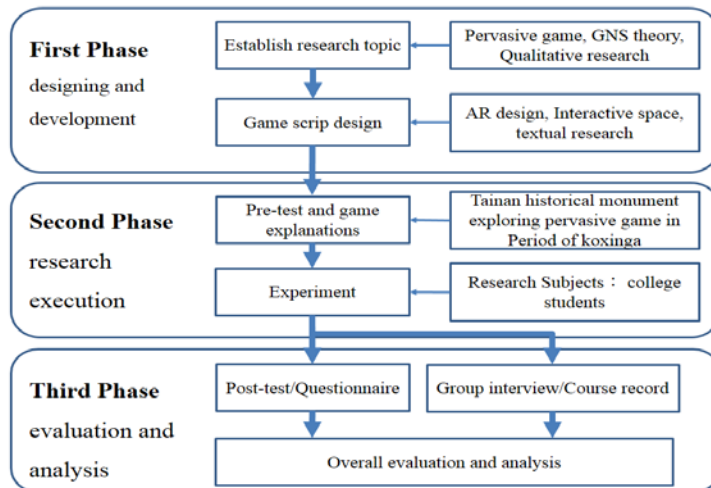


Figure 3. Research Process

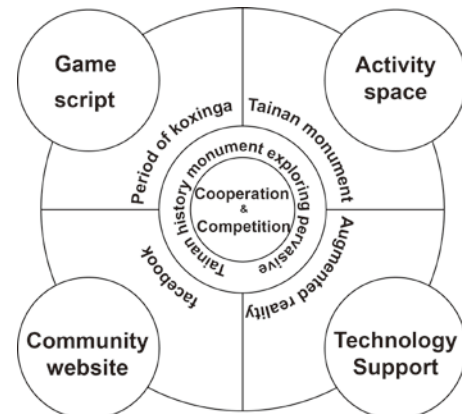


Figure 4. Game Structure.



Figure 5. Game message publication.



Figure 6. Behavioral observations.

4. Game Design

4.1 Script Design

In accordance with the contribution during Period of Koxinga, the game is divided into four sections in terms of content: Battle, Construction, Education, and Sentiment. Players in the game may be soldiers, architects, civilian, or students.

In 1661, Zheng Chenggong landed on Luerhmen in Taiwan, and marched to Provintia where is today's Chihkan Tower. In the game, when players were soldiers, each team competes with others to occupy markers in the tower, and then report the information and situation to their team members as soon as possible. After attacking and occupying Provintia, the next mission is to take down another military base, Zeelandia.

Players are then brought to the year 1666 when they play the role of architects to build Tainan Confucius Temple. Players have to find out the original blueprint and construction list in Tainan Confucius Temple to begin with. There are about thirty architectural elements on the list. After finding the elements, the players should take a picture and post it on the Facebook as a proof. Other players can use the “comment” function to introduce the architectural element’s function or hidden meaning, and use “like” to vote for the best description.

As Tainan Confucius Temple was built, the imperial examination was implemented formally. Confucianism started to flourish rapidly. There were two lessons for the players to attend. One is for the players to act as students attending the Great Learning in Ming Lun Tang where was used as the classroom. Another lesson for the player is to learn and record Six-Row dance in front of Dacheng Palace and then uploaded the video to the Facebook.

As Zheng Chenggong took Taiwan as the revival base, he still could not overcome the illness and the arrival of Qing Dynasty. Before surrender, Prince of Ningjing’s concubines died for the loyalty of their husband and country. The story became a taboo during Qing Dynasty. People gradually forgot about the tragedy except an old tree in Five Concubines Temple. The tree knew everything and turned this memory into pieces hidden in the temple. Players have to look for the old tree and put the pieces together to retrieve the lost memory.

4.2 Technology Implementation

The game is designed to encourage players to actively explore the information as they really need them rather than guide them to the learning materials they aren’t interested in. In order to make the exploration more intuitive, markerless AR is employed. Learning contents embedded in the AR are in the forms of game props, stories, and map hints.

Game props are objects used for gaining game points. Stories are told by the historical relics unlike TimeWarp using a virtual spirit to guide the exploration. In this game, the narrators of the stories are those existed in the history. For example, when the player comes to the stone statue (Figure 7), he uses the smart phone to scan it to retrieve the AR information. The learning content includes the name and the stories about the statue. Another example is when the player reaches the temple door (as Figure 8), the door gods will explain the meaning of the objects they hold and stories about what happened during their guidance. Map hints are those when the player scans the map, it will reveal the hidden objects and locations (as Figure 9). Players then have to find out the blueprint.



Figure 7. Stone statue of Tainan Confucius Temple.



Figure 8. Five Concubines Temple door gods

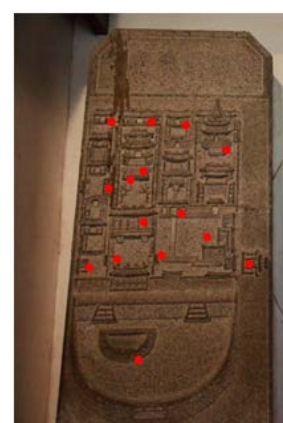


Figure 9. Tainan Confucius Temple blueprint and virtual tag

5. Research analysis

The pretest and posttest are used to estimate the learning effectiveness. Questionnaire is used to collect data. The questionnaire includes three parts. The first part is the learners’ prior experience including the experience of using AR and Facebook to see whether players’ game experience and technology

application use would influence the effectiveness of the pervasive game activity. The second part is considering the AR application, presentation, and content in the game. The third part is the influence of pervasive game to the exploration of Tainan historical monuments. The questionnaire is divided into three aspects, Technology, Culture, and Gameplay. Last, focus group interviews and community website records are used to assess students' feelings and behaviors toward the game.

6. Conclusion

E-learning is a modern and unavoidable learning method. Along with mobile technology, learners can approach the learning content and environment more directly outside of the classroom. In problem-based mobile learning activities, learners are mostly guided passively through the activities. Some learners do not immerse themselves in the learning environment and have low learning motivations.

In this research, players are guided to explore the historical monuments actively through the pervasive game and use AR technology to experience more interactions. Players will have an in-depth knowledge of the history of Zheng Family Dynasty as well as the Tainan monumental architecture. Through the game, players interact with the monuments and other players. With the application of markerless AR, getting information from the environment is more easily and intuitive. Using Facebook for social interactions can dispense the time to learn new tools. Not only players' game play process can be recorded on the server, their personal output of game experiences can also be shared to their family and friends to achieve knowledge dissemination.

Acknowledgements

This study is supported in part by the National Science Council of the Republic of China, under NSC 98-2511-S-024-006-MY2 and NSC 100-2628-S-024-002 -MY3.

References

- Azuma, R. T.(1997). A survey of augmented reality. *Presence-Teleoperators and Virtual Environments*, 6(4), 355-385.
- Barkhuus, L., Chalmers, M., Tennent, P., Hall, M., Bell, M., Sherwood, S., & Brown, B. (2005). Picking pockets on the lawn: the development of tactics and strategies in a mobile game. In *UbiComp 2005: Ubiquitous Computing* (pp. 358-374). Springer Berlin Heidelberg.
- Bell, M., Chalmers, M., Barkhuus, L., Hall, M., Sherwood, S., Tennent, P., Brown, B., Rowland, D., Benford, S., Hampshire, A. & Capra, M. (2006). Interweaving mobile games with everyday life. In *Proceedings of the SIGCHI conference on Human Factors in computing systems* (pp. 417-426). ACM.
- Benford, S., Rowland, D., Flintham, M., Drozd, A., Hull, R., Reid, J., Morrison, J. & Facer, K. (2005). Life on the edge: supporting collaboration in location-based experiences. In *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 721-730). ACM.
- Chen, C. P. & Shih, J. L. (2012). A Prototype on a Meta-model for Designing Instructional Pervasive Games. In Sugimoto, M., & Alevan, V. (Eds.), *Proceedings of Fourth IEEE International Conference on Digital Game and Intelligent Toy Enhanced Learning*, (pp. 47-51). Kagawa, Japan: Conference Publishing Services.
- Cheok, A., Goh, K. H., Liu, W., Farbiz, F., Fong, S. W., Teo, S. L., Li, Y., and Yang, X. (2004). Human Pacman: a mobile, wide-area entertainment system based on physical, social, and ubiquitous computing. *Personal Ubiquitous Comput.* 8, 2, 71-81
- Dyson, B., Griffin, L. L., & Hastie, P. (2004). Sport education, tactical games, and cooperative learning: Theoretical and pedagogical considerations. *Quest*, 56(2), 226-240.
- Edwards, R. (2003) GNS and other matters of role-playing theory. retrieved from <http://www.indie-rpgs.com/articles/3/>.
- Gentes, A., Guyot-Mbodji, A., & Demeure, I. (2010). Gaming on the move: urban experience as a new paradigm for mobile pervasive game design. *Multimedia Systems*, 16(1), 43-55.
- Herbst, I., Braun, A. K., McCall, R., & Broll, W. (2008). TimeWarp: interactive time travel with a mobile mixed reality game. In *Proceedings of the 10th international conference on Human computer interaction with*

- mobile devices and services (pp. 235-244). ACM.
- Huang, H. C., Shih, S. G., & Lai, W. C. (2011). Cooperative Learning in Engineering Education: a Game Theory-Based Approach. *International Journal of Engineering Education*, 27(4), 875-884.
- Huizenga, J., Admiraal, W., Akkerman, S., & ten Dam, G. (2009). Mobile game-based learning in secondary education: engagement, motivation and learning in a mobile city game. *Journal of Computer Assisted Learning*, 25(4), 332-344.
- Jegers, K. (2009). Pervasive gameflow-identifying and exploring the mechanisms of player enjoyment in pervasive games. Unpublished Doctoral Dissertation, Umea University, Sweden.
- Laine, T. H., Sedano, C. A. I., Joy, M., & Sutinen, E. (2010). Critical Factors for Technology Integration in Game-Based Pervasive Learning Spaces. *Ieee Transactions on Learning Technologies*, 3(4), 294-306.
- Lindt, I., & Broll, W. (2004). NetAttack – First Steps Towards Pervasive Gaming, *ERCIM NEWS Special Issue on Games Technology*, 57, 49-50
- Montola, M. (2011). A ludological view on the pervasive mixed-reality game research paradigm. *Personal and Ubiquitous Computing*, 15(1), 3-12.
- Okazaki, S., Skapa, R., & Grande, I. (2008). Capturing Global Youth: Mobile Gaming in the U. S., Spain, and the Czech Republic. *Journal of Computer-Mediated Communication*, 13(4), 827-855.
- Piekarski, W., & Thomas, B. (2002). ARQuake: the outdoor augmented reality gaming system. *Communications of the ACM*, 45(1), 36-38.
- Pragnell, M. V., Roselli, T., & Rossano, V. (2006). Can a hypermedia cooperative e-learning environment stimulate constructive collaboration? *Educational Technology & Society*, 9(2), 119-132.
- Schwabe, G., & Göth, C. (2005), Mobile learning with a mobile game: design and motivational effects. *Journal of Computer Assisted Learning*, 21(3), 204-216.
- Sweetser, P., Wyeth, P. (2005) GameFlow: a model for evaluating player enjoyment in games. *ACM Computers in Entertainment*, 3(3).
- Walther, B. K. (2005). Notes on the methodology of pervasive gaming. In F. Kishino, Y. Kitamura, H. Kato & N. Nagata (eds.), *Entertainment Computing - Ichc 3711*, 388-495.
- Walz, S., Ballagas, R., Borchers, J., Mendoza, J., Kratz, S., Wartmann, C., Fuhr, C., Tann, M., Shin, D., Hameed, B., Bardos, L., & Hovestadt, L. (2006). Cell Spell-Casting: Designing a Locative and Gesture Recognition Multiplayer Smartphone Game for Tourists. *PERGAMES, Third International Workshop on Pervasive Gaming Applications at PERVASIVE 2006*, Dublin, Ireland.
- Ballagas, R., Kuntze, A., & Walz, S. P. (2008). Gaming tourism: Lessons from evaluating reexplorer, a pervasive game for tourists. In *Pervasive computing* (pp. 244-261). Springer Berlin Heidelberg.

Designing a Farming Game with Social Design to Support Learning by Reciprocal Questioning and Answering

Yih-Ruey JUANG*

Dept. of Information Management, Jinwen University of Science and Technology, Taiwan, R.O.C.

**yrjuang@just.edu.tw*

Abstract: Most of learners usually hesitate and tend to keep silence in online discussion for learning in traditional e-Learning platform, but they are enthusiastic about posting messages and playing games in social networking sites. By taking the advantages of social learning games, this article presents an initial study on designing a farming game “The Secret Garden of Angels” with a social interaction strategy which is modeled from an icebreaker game ‘The Little Angel and Master’ in real world. The learning mechanism integrated into the game is learning by reciprocal questioning and answering. Through playing interesting farming game with classmates, the social learning game attempts to raise the learning motivation, interaction between teachers and students and among students, and then the learning achievement.

Keywords: Farming game, social learning, reciprocal teaching, reciprocal questioning and answering.

1. Introduction

Many recent researches have proven that students can gain positive learning outcome when using game based learning (Gee, 2003; Ulicsak, 2010; Ebner and Holzinger, 2007; Kim, Park and Baek, 2009; Papastergiou, 2009; Chen et al., 2011; Yien et al., 2011). By referring to NTL’s (National Teaching Laboratory Institute) learning pyramid, learning by ‘practice by doing’ will gets 75% retention rate and learning by ‘teaching other or immediate use of learning’ will gets 90% retention rate, where traditional lecture and reading just get 5% and 10% retention rate (Magennis and Farrell, 2005). Game based learning is a practical method similar to learning by ‘practice by doing’ in a way. According to the FutureLab’s (2010) survey, the main reasons of the adoption of game-based learning are to engage students and offer an alternate way of teaching. Through creating an immersive learning environment, students will be interested in learning and gain better outcome.

Most educational game is also called as a serious game that “does not have entertainment, enjoyment, or fun as their primary purpose” (Michael and Chen, 2005). But the most important issue we need to address is the students’ better willingness of playing educational games constantly without any pressure. We believe a good approach to learning should explicitly grasp student’s need and interest, or the meaningful learning will not occur as expected. Besides, teachers and parents often worry about how students can really learn something from games. How to design an educational game that can appropriately balances the entertainment and meaningful learning is an important issue in research of game-based learning.

In recent years, social networking services, such as Facebook, Twitter, MSN, and Plurk, are very popular to connect friends in daily life. One of the attractive factors is people can easily keep in touch with their friends in real world and can conveniently extend their social network to other strangers through playing social games (NM incite, 2011). By taking the advantage of the popularity of social networking games, this article introduces a novel design concept of farming game “The Secret Garden of Angels.” The social design of the game is adapted from an icebreaker of the real world, and integrates a domain-independent learning strategy into it. Through peer reciprocal questioning and answering, the learners will earn money and experience points to buy and plant more high valuable crops for

accumulating personal achievement. The significant aim of this social learning game is to facilitate meaningful interaction of learning among learners by sense of achievement, competition, and fun.

2. Designing the Game “The Secret Garden of Angels”

2.1 Background: The Angel and Master - a Real World Icebreaker Game

This initial idea of the social learning game comes from a real world icebreaker game “The Angel and Master.” Everyone who joins the game serves as an *angel* of someone called the *master*. Every angel is also a master of some angel. The angel’s mission is to actively and positively care for the master’s daily life, such as schoolwork support, health care, social activity invitation, tips on school life, and so on. One important rule is the angels cannot expose identity to their masters while doing anything. Moreover, everyone can play as a *passer-by angel* to care the other masters he/she likes to interact with, but is allowed to expose identity. This rule makes the participant with high popularity has more chances to interact with everyone.

The most interesting time is the “Thankful Meeting Day” in the end of this game. The identity of every master’s angel will be publicly announced after each master has expressed thankfulness or complaint for his or her angel. It will be a grateful and funny day. Through this icebreaker game, every participant will be more familiar with each other. By borrowing the idea of this game, the game “The Secret Garden of Angels” adapts the interactive mode to design the peer reciprocal teaching.

2.2 Learning by Reciprocal Questioning and Answering

Reciprocal teaching proposed by Palincsar and Brown (1984) is an instructional activity to facilitate interaction between teachers and students in dialogue form for constructing the meaning of text. The students are asked to play as a teacher in turn to lead the dialogues by four strategies: questioning, clarifying, summarizing, and predicting. Based on the concept of reciprocal teaching, Juang and Chan (2013) proposed a learning strategy that integrates reciprocal questioning and answering into a learning process with three stages. In the questioning stage, learners are asked to preview learning material, and ask questions on the system before entering classroom. After classroom learning, the learning process enters into the answering stage. Each student is assigned to answer some anonymous questions the system randomly allotted from those questions asked in the questioning stage. Finally, in the assessing stage, all questions and answers are public for reading, re-answering, and assessing by all learners and teachers of the course. Since all learners will publicly assess all questions and answers, learners are expected to pay regard to the quality and correctness of their posts.

The features of the learning by reciprocal questioning and answering emphasize on the lesson preview before classroom learning, two-phase answering, and comprehensive assessment. First, learners will be more engaged in classroom learning if they have previewed the lessons before entering the classroom. Through browsing those questions posted by learners, the teacher can easily conclude an approximation of learners’ starting point for learning the new lessons. Second, two-phase answering insures that each question has assigned to one learner for answering in double-blind interaction mode, and then engages learners in open discussion of second phase. Two-phase answering also avoids plagiary of answers in answering stage. Third, comprehensive assessment gives learners a soft constraint to be serious about their questioning and answering.

2.3 Main Script of the Game “The Secret Garden of Angels”

“The Secret Garden of Angels” is a farming game which interaction model is designed by referring to the icebreaker game “The Angel and Master.” Players of this game can regard a farm as a course, a farm host as a teacher, and a farmer as a student. Every player can create a farm to be the host or join an exist farm to be a farmer. The first task of a teacher, the farm host, is the pairing of angels and masters. The teacher has three choices for pairing according to: gender segregation, no gender segregation, and

learning achievement. For examples, a male master should be assigned with a female angel; a farmer with low learning achievement should be assigned with an angel with high learning achievement.

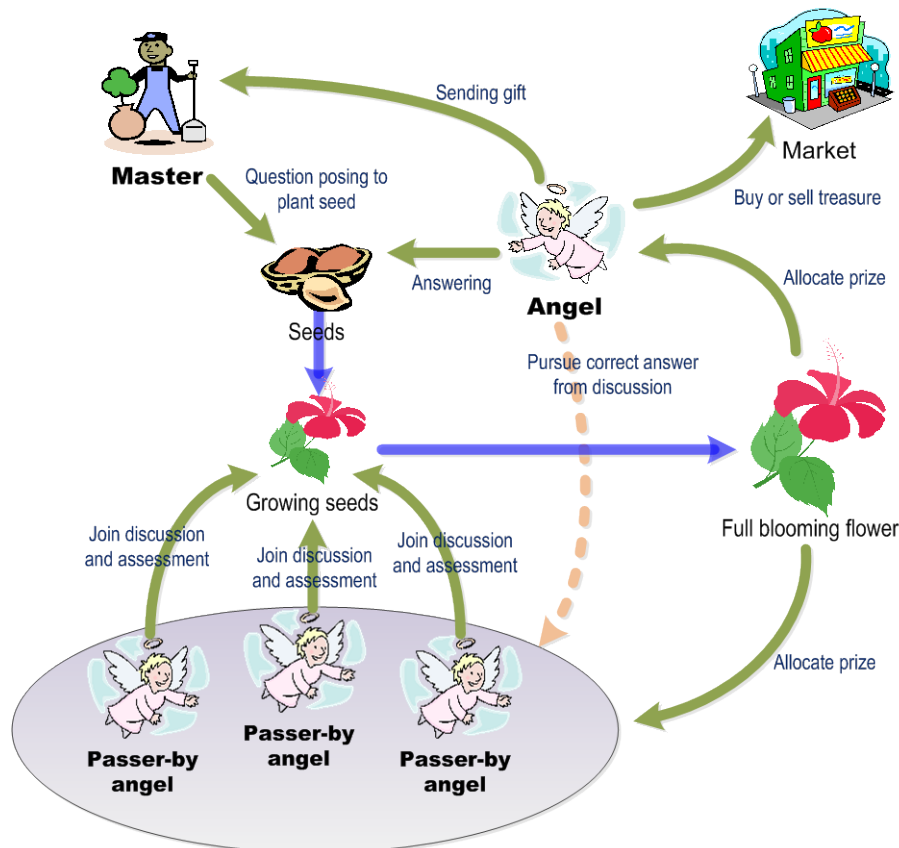


Figure 1. The game operation flow.

After planting seeds on cropland, time for growing seeds is started. In this time, every farmer can visit other farmers' cropland and click seeds to get into discussion. That is the passer-by angels who are not anonymous to the master can provide different answers. While discussing questions in seeds, all messages of discussion will be assessed by clicking "like" or "unlike" buttons in the individual question. The passer-by angels who join the discussion will earn experience points if the "like" button of his or her message has been clicked.

After the growing time, the angel and passer-by angels who join the discussion in a seed will share the prize according to the setting value of the seed. The original angel will earn 50% prize and the passer-by angles will share another 50% prize. The players can use the prize money to buy seeds, decoration, or gifts for personal collections or sending them to others. The experience points are used to represent personal performance of participation so as to provide teacher a reference of evaluating students. Therefore, the angels should endeavor to find out the answers for their masters and the masters should reply actively and positively to earn more prize and experience points.

This farming game has been designed by Flash, a 2D animation tool, and embedded in Facebook, a popular social networking site. Anyone who has Facebook account can play this game directly after a short registration process. Players can create a farm to be a teacher and has some

management tools to operate each cropping period (see Figure 2). Also, the players can join in other farms as a student and have some management tools for communication, shopping, recording, and ranking (see Figure 3).



Figure 2. Main page of the farm host (teacher)



Figure 3. Main page of the farmer (student)

3. Research Design

The research questions of this farming game are listed below:

1. Is the game valid to raise the performance of students' preview of lessons before classroom learning?
2. Can the social design of the game facilitate students' online positive interaction for learning?
3. Can the learning strategy raise the learning outcome?

This study will adopt quasi-experimental research method with pretest and posttest to explain the third question related to students' learning outcome. The pretest will be a background knowledge test to evaluate whether both control group and experimental group have the approximate ability to learn the new lessons. The posttest will be a midterm or final exam that aims at the long-term learning achievement after several cropping periods.

Moreover, in order to answer the first and second question, this study will develop a questionnaire survey based on the framework proposed by de Freitas and Oliver (2006). The framework provides four dimensions for evaluating games- and simulation-based education. The first dimension is the *context* where the play/learning takes place. The second dimension is the *learner specification* including the learning background, style and preferences. The third dimension is the *mode of representation* which reveals how the game affects the learners' internal process of critical reflection. The fourth dimension is the *pedagogical consideration* including the learning processes during both the formal learning time and informal learning time. By considering the four dimensions, the questionnaire aims to survey the degree of satisfaction of learners in learning motivation, person interactivity, online interactivity, and sense of learning achievement.

Besides, to survey the details of how the learning and reflection occurred in embedding game playing into course, this study will invite some participants with heterogeneous attributes to join the focus group interview. The results can provide qualitative evidence to explain whether the game design is appropriate for learners.

4. Conclusion

Social learning game is of high potential to attract students' interest in learning by playing the game they are conversant with. This initial exploration of a framing game with social design provides a touchstone of the possibility of designing a domain-independent learning activity into a game. Although the farming game is a well-known game to many students, the author believes this will reduce the learning difficulty for beginners. Teachers and students are willing to try the game just using their conventional operation concept. Then, they will pay much attention on the learning activities embedded in the game.

Acknowledgements

This work was supported by the National Science Council of Taiwan, Republic of China, under grant NSC 101-2511-S-228 -001 -MY2.

References

- Chen, W. F., Wu, W. H., Chuang, T. Y., & Chou, P. N. (2011). The effect of varied game-based learning systems in engineering education: An experimental study. *International Journal of Engineering Education*, 27(3), 482-487.
- de Freitas, S., & Oliver, M. (2006). How can exploratory learning with games and simulations within the curriculum be most effectively evaluated? *Computers & Education*, 46(3) 249-264.
- Ebner, M., & Holzinger, A. (2007). Successful implementation of user-centered game based learning in higher education: An example from civil engineering. *Computers & Education*, 49(3), 873-890.
- Futurelab (2010). Game-based learning survey. Retrieved Dec. 22, 2011, from http://archive.futurelab.org.uk/resources/documents/project_reports/Games_survey_analysis_report.pdf
- Gee, P.J. (2003). *What video games have to teach us about learning and literacy*. NY: Palgrave Macmillan.
- Junag, Y. R., & Chan, J. (2013, May). *Cooperative learning with all classmates by peer-questioning, answering, and assessing*. Paper presented at The 17th Global Chinese Conference on Computer in Education, Beijing, China.
- Kim, B., Park, H., & Baek, Y. (2009). Not just fun, but serious strategies: Using meta-cognitive strategies in game-based learning. *Computers & Education*, 52(4), 800-810.
- Magennis, S., & Farrell, A. (2005) Teaching and learning activities: Expanding the repertoire to support student learning. In G. O'Neill, S. Moore, & B. McMullin (Ed.), *Emerging issues in the practice of university learning and teaching*, Dublin: AISHE.
- Michael, D., & Chen, S. (2005). *Serious games: Games that educate, train, and inform*. Boston: Thompson Course Technology PTR.
- NM Incite (2011). Friends & frenemies: Why we add and remove Facebook friends. Retrieved Dec. 26, 2011, from <http://www.nmincite.com/?p=6051>.
- Palincsar, A. S., & Brown, A. L. (1984). Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction*, 1(2), 117-175.
- Papastergiou, M. (2009). Digital game-based learning in high school computer science education: Impact on educational effectiveness and student motivation. *Computers & Education*, 52(1), 1-12.
- Ulicsak, M. (2010). Game in education: Serious games. A FutureLab Literature Review. Retrieved Dec. 12, 2011, from <http://archive.futurelab.org.uk/projects/games-in-education>.
- Yien, J. M., Hung, C. M., Hwang, G. J., & Lin, Y. C. (2011). A game-based learning approach to improving students' learning achievements in a nutrition course. *Turkish Online Journal of Educational Technology*, 10(2), 1-10.

The effect of the Mozart music on learning anxiety and reading comprehension on Chinese storybook reading

Yen-Ning Su^a, Chia-Cheng Hsu^a, Chia-Ju Liu^b, Yueh-Min Huang^{a*} & Yu-Lin Jeng^c

^a *Department of Engineering Science, National Cheng Kung University, Taiwan*

^b *Institute of Science Education, National Kaohsiung Normal University, Taiwan*

^c *Cloud System Software Institute, Institute for Information Industry, Taiwan*

*huang@mail.ncku.edu.tw

Abstract: Reading ability is the basic skill to enhance the competitiveness of the national economy. Through a large number of reading content, students can develop high-level thinking skills. Anxiety is an import factor to affect students' learning when they are reading materials. Some studies found suitable music can reduce people stress feeling. In order to investigate the effectiveness of music on learning, this study used Mozart music in a reading process with Chinese storybook. The results show that Mozart music has an impact on the improvement of students' reading comprehension. However, we also found that the Mozart music couldn't reduced the students' learning anxiety in our study.

Keywords: Mozart music, Learning anxiety, Reading Comprehension, Chinese storybook, Elementary school student

1. Introduction

The national reading ability is closely related to the competitiveness of the national economy and the cultural level. Enhancing students' reading ability has become a key policy of all the countries in the basic education stage. The appraisal report of the 2009 Programme for International Student Assessment (PISA) presented that the ranking of Taiwan students' reading literacy slipped to 23 in 2009 from 16 in 2006, and lost in Shanghai, Hong Kong, Singapore and Japan on the overall performance in Asia (Perkins, Moran, Cosgrove, & Shiel, 2011). The result shows that other Asian countries are committed to enhance reading ability of their students. It is crucial that Taiwanese government needs to face squarely the problems of reading-related issues in education.

Chall (1983) divided the development of children's reading into six stages which are divided two parts that are the former third-grade "learning to read" stage, and elementary school after the fourth grade "learning from reading" stage. The main task of the former is to learn how to read, and the latter is to learn a variety of knowledge by using reading as a tool. For the elementary school students after the fourth-grade, they will have more opportunities to handle a large messages and resources, if they can correctly and efficiently learn through reading and develop high-level thinking skills. Moreover, Chall (1996) proposed the developmental stage of reading ability, and the sixth grade students of elementary school correspond with the third stage, reading for the new, to absorb knowledge by reading. Students in the stage read more vocabularies and quickly accumulate a large of words to increase the prior knowledge. If the students failed to understand the reading content, they may reduce the opportunity to capture the new knowledge, and thereby affect learning academic performance.

Reading is one part of language learning. Arnold (2000) addressed that anxiety plays an important position in language learning. The research shows that the mild anxiety is able to stimulate learning. However, the high anxiety significantly reverses the learning, and interfere the thinking process of students.

Using music to relieve anxiety has been confirmed in areas of medical research, and the types of music include the classic music, the new century music, and the popular music (Cooke, Chaboyer, Schluter, & Hiratos, 2005; Lee, Henderson, & Shum, 2004). These studies have proved that the music has the effect of reducing anxiety and has an impact on learning. Rauscher et al. (1993) pointed out that

Mozart's music can briefly enhance students' spatial reasoning ability. Dosseville, Laborde, and Scelles (2012) found that the learning performance of the students by listening music was better than that of the students without listening to music. Therefore, reading with using background music to help learning may be an important factor. Based on those studies, the aim of this study is to explore the impact of using Mozart music for elementary school students' reading on the learning anxiety and reading comprehension.

2. Research Methods

2.1 Participants

In this study, 33 senior-grade students (19 males and 14 females) in elementary school in south Tainan were recruited to participate the learning task. The participants had no experience of reading the learning materials in the learning tasks, and some students had the learning disability or the students who did not finish the experimental procedure, their experimental data were invalid and were eliminated. Therefore, 31 experimental data were used for analysis, which included 18 males and 13 females.

2.2 Experimental tools

The learning materials were two articles in the format of Chinese expository prose from Taiwan government (MOE, 2011), and their titles were "The Glacier" and "The Rock Climbing". First article (The Glacier) with a total 1,206 words, the average words per sentence was 10.95 words, and the word frequency was 99.42% within the 5,021 Chinese common words which have been reported in an elementary school survey of common words (MOE, 2000). Second article (The Rock Climbing) with a total 1,199 words, the average words per sentence was 11.1 words, and the word frequency was 99.58% within the same set of common words. The use of an above level text was to ensure that students would read such a text were proper their word recognition ability, thus preventing a ceiling effect in word recognition for less or better readers.

After the end of each article, a test unit was used to test the reading comprehension of the article. Reading comprehension test of each article had a total score of 18 points, these two reading comprehension tests were used as experimental tools to measure students' reading comprehension. According to the item difficulty results of the two articles range from 0.6 to 0.7, means that the item difficulty level of the two articles is medium-easy.

This study used a scale of learning anxiety to analyze the learning anxiety of participants. We revised leaning anxiety scale according to the two previous studies (Venkatesh, 2000; He, Cheng, & Liu, 2010). The scale consisted of 8 items of question that were used to access the score of students' learning anxiety when they finished each reading task. Responses to all questions were on a four-point Likert-scale, from 4 for strongly agree to 1 for strongly disagree, thus the score range of learning anxiety that from 4 to 32 and a higher score means less learning anxiety of a student. The Cronbach's α of this scale was 0.91, indicating that the scale has a good internal consistency.

2.3 Experimental design and procedure

In this study, we used equivalent-time-sample design to investigate both the students' learning anxiety and reading comprehension after all participants completed the learning task. The learning task with the background music was assigned to use Mozart's Sonata for two pianos K.448, and another task having without the Mozart music was the "silent task". In other words, all the participants completed the first reading task about fifty minutes, including reading the article "The Glacier", took a learning anxiety scale and a reading comprehension test. A week later, the participants completed the second reading task also about fifty minutes, including reading the article "The Rock Climbing" with using Mozart Sonata as background music, took a learning anxiety scale and a reading comprehension test. The experimental design was shown in Table 1.

Table 1. Experimental design

Task	Test	Time interval	Task	Test
T ₁	O ₁	X	T ₂	O ₂

Note:

X : The interval time is a week

T₁: All participants read material (The Glacier) without Mozart music

T₂: All participants read material (The Rock Climbing) with Mozart music

O₁, O₂: Test (learning anxiety scale, reading comprehension test of each article)

Figure 1 shows that learning task in the experimental procedure. Figure 1a shows the students in a Chinese storybook learning task, and Figure 1b shows that the personal computer and speaker were used to play Mozart's Sonata for two pianos K.488.



a. Learning task



b. Play Mozart music

Figure 1. Experimental procedure

3. Results and discussion

At the beginning of the experiment, 31 students participated in the learning task, and their experimental data were used for analysis, which included 18 males and 13 females. The experimental results are shown in Tables 2 and 3.

As shown in Table 2, we found that no significant differences between two tasks on the score of students' learning anxiety. It appeared that the Mozart music didn't affect the students' learning anxiety in reading Chinese expository prose.

Table 2. The t-test results on learning anxiety

Music	Learning tasks			t	d
	<u>N</u>	<u>M</u>	<u>SD</u>		
Mozart music	31	25.23	4.92	.575	0.06
Silence	31	24.90	5.33		

Note: The "N" representation of the number of participants. "t" means the t-test value. "d" means the effect size. "M" means the mean value and "SD" means the standard deviation.

As shown in Table 3, similarly, we found that the reading comprehension score for the Mozart music task was significantly higher than that for the silent task. It appeared that the Mozart music has the impact on the students' reading comprehension when they read Chinese expository prose. These experimental values are similar to the previous study that Mozart music has an impact on students' learning (Rauscher et al, 1993).

Table 3. The t-test results on reading comprehension

Music	Learning tasks			<u>t</u>	<u>d</u>
	<u>N</u>	<u>M</u>	<u>SD</u>		
Mozart music	31	9.90	4.03	6.047***	0.88
Silence	31	6.65	3.36		

Note: *** $p < .001$, the "N" representation of the number of participants. "t" means the t-test value. "d" means the effect size. "M" means the mean value and "SD" means the standard deviation.

Based on our finding, we found that Mozart music can greatly enhance students' reading comprehension performance which is consistent with the findings of the past research (Rauscher et al., 1993). Although the learning anxiety in the two background music groups was not significantly different, the learning anxiety in the Mozart music group is lower than that in the silent group. The result of learning anxiety may be associated with the formal curriculum of the elementary school in Taiwan. The high grade students in elementary school had the experience of reading program for several years so that the two groups' learning anxiety about the reading Chinese storybook task presented little differently. Our study focused on investigating the relationship between the Mozart music and the reading task with learning anxiety and reading comprehension. The reading curriculum in elementary school contains not only reading task but also reading test. Therefore, the future research will consider using Mozart music in the reading test to understand the impact of music on students' test anxiety. We hope a series of studies about Mozart music can help understand the effect of music on students' reading when they receive different situational tasks.

4. Conclusions

In this study, we investigated how music-related factors (Mozart music and silent) affect learning anxiety and reading comprehension in reading Chinese storybook by using 31 elementary school students in the learning tasks. Based on the experimental results, The results show that Mozart music has an impact on the improvement of students' reading comprehension. However, we also found that the Mozart music couldn't reduced the students' learning anxiety in our study. Thus, we suggest that students can read Chinese storybooks with Mozart music to help them effectively acquire knowledge. The limitation of this study is a small of students in this experiment. In the future research, we will consider some experiments with a greater number of students, and conduct more complete research to investigate the relationships between e-books and Mozart music.

Acknowledgements

This study is conducted under the " Cloud computing systems and software development project(2/3)" of the Institute for Information Industry which is subsidized by the Ministry of Economy Affairs of the Republic of China and the National Science Council (NSC), Taiwan, ROC, under contracts No. NSC 100-2511-S-006-014-MY3, NSC 102-2811-S-006-002, NSC 101-2511-S-041-001-MY3, and NSC 101-3113-P-006-023-.

References

Perkins, R., Moran, G., Cosgrove, J., & Shiel, G. (2011). *PISA 2009: The Performance and Progress of 15-year-olds in Ireland*. Retrieved December 14, 2011, from

- <http://www.oireachtas.ie/documents/committees30thdail/j-educationscience/presentations/2011/document1.pdf>
- Arnold, J. (2000). Seeing through listening comprehension exam anxiety. *TESOL Quarterly*, 34(4), 777-786.
- Chall, J.S. (1983). *Stages of Reading Development*. New York: McGraw-Hill.
- Chall, J.S. (1996). *Learning to Read: The Great Debate* (1967). New York: McGraw Hill.
- Cooke, M. Chaboyer, W., Schluter, P. & Hiratos, M. (2005). The effect of music on preoperative anxiety in day surgery. *Journal of Advanced Nursing*, 52(1), 47-55.
- Lee, D., Henderson, A. & Shum, D. (2004). The effect of music on preprocedure anxiety in Hong Kong Chinese day patients. *Journal of Clinical Nursing*, 13(2), 297-303.
- Rauscher, F., Shaw, G., KY, C.N. (1993). *Music and spatial task performance*, 265, 611-612.
- Dosseville, F., Laborde, S., & Scelles, N. (2012). Music during lectures: Will students learn better?. *Learning and Individual Differences*, 22(2), 258-262.
- Ministry of Education, Republic of China. (2000). *Elementary School Survey of Common Words Report*. Retrieved April 25, 2011, from http://www.edu.tw/files/site_content/M0001/primary/shindex.htm?open
- Ministry of Education (2011). *Reading comprehension: examples of articles and reading comprehension test*. Ministry of Education : Taipei.
- Venkatesh, V. (2000). Determinants of Perceived Ease of Use: Integrating Control, Intrinsic Motivation, and Emotion into the Technology Acceptance Model. *Information Systems Research*, 11(4), 342-365.
- He, Y.Y., Cheng, C.K., & Liu, B.J. (2010). Teaching Computer Programming for Freshmen: A Study on Using Scratch as Remedial Teaching. *International Journal on Digital Learning Technology*, 2(1), 11-32.

Using Augmented Reality to Assist an Interactive Multi-Language Learning System in an Elementary School

Gwo-Haur HWANG*, Chen-Yu LEE, Hen-Lin HWANG, Guan-Lin HUANG, Jheng-Yi LIN & Jun-Jie CAI

Department of Information Networking and System Administration, Ling Tung University, Taiwan

*ghhwang@mail.ltu.edu.tw

Abstract: Second/foreign language learning has been a sustained concern due to competitiveness and globalization. Commonly, elementary school students in Taiwan learn not only their native language such as Mandarin but also English and Hokkien. It is not easy to acquaint students with multiple languages at the same time. Therefore, the solution to raise the students' interests and learning effectiveness during multi-language learning has been a hot issue. Augmented reality (AR) is a technology that blends virtual contents with the real environment, and it supports the context-aware ubiquitous learning. The application of AR is considered helpful to increase the students' motivations by past researchers. However, most researches focus on bilingual learning including Mandarin and English, and some specific learning objects (such as image cards) are needed to provide. Accordingly, an interactive multi-language learning system is proposed in this study to improve the inadequate parts mentioned above. It is expected to promote students' motivation and learning effectiveness.

Keywords: Second/foreign language learning, multi-language learning, augmented reality, context-aware ubiquitous learning, learning effectiveness

1. Introduction

Due to the growing trend of globalization, it is necessary to exchange information and communicate with people all over the world. Because language is the basis of communication, the necessity of second/foreign language learning to raise personal competitiveness to meet the global trend has become a sustained concern.

Commonly, elementary school students in Taiwan learn not only their native language such as Mandarin but also English and Hokkien. It is not easy to acquaint students with multiple languages at the same time. Therefore, the solution to raise the students' interests and learning effectiveness during multi-language learning has been a hot issue.

In the past, second/foreign language learning relied upon teachers' lecturing to explain the learning materials of textbooks (Savignon, 1988). It is possibly a severe test to teacher's presentation skills in the traditional teaching environment. Besides, no consideration of differences of students' abilities, traditional teaching may result in the students' cognitive load because of the poor level of prior knowledge. Due to the advance of technology, the increasing popularity of mobile devices enables learners to learn whenever and wherever without the restriction of time and place.

Augmented reality (hereafter abbreviated as AR) is a technology that allows the presentation of the real world with virtual objects superimposed upon or virtual objects composited with the real world (Azuma, 1997). AR has been applied so far in various research fields including language learning. Hsieh and Lin (2009) proposed an AR-enhanced English vocabulary learning system. Tsai, Li and Wu (2011) proposed an AR-enhanced Chinese learning system. Students can interact with the virtual objects in real word and learn more. Hence, students will have more fun and willingness to learn as well as impressive experience. These systems only supported single language learning, and some specific learning objects (such as image cards) need to be provided. However, it could not meet the requirements of students for learning multi-language in Taiwan.

Accordingly, an interactive multi-language learning system is proposed in this study. This system allows students learning multi-language in real environment without additional learning objects. It is expected to stimulate students' motivation, promote the learning effectiveness, and assist students to review the learning contents after school.

2. Literature Review

2.1 Language Learning

Clark and Paivio (1991) proposed a dual-coding theory. According to the theory, the way of people to process information is divided into two systems. One is the verbal system, and another one is the non-verbal system. In the verbal system, learning is in the way such as speaking, writing, or listening. In the non-verbal system, it uses the way to learn by graphics, sound, video, and even human emotions. In non-verbal system, learners can absorb related information to current study at the same time, so it allows more direct association of learning. Hence, it is helpful not only to reduce the cognitive load but also to be inferred from this association to impress and learn.

2.2 Development of Context-Aware Ubiquitous Learning

In recent years, there is an increasing possession of portable devices including smart phones, tablet PC (personal computer), pocket PC, PDA (personal digital assistant), and any devices which can be loaded digital information. Tatar, Roschelle, Vahey and Penuel (2003) proposed a notion named ubiquitous computing, and the concept was that the lightweight powerful networking and communications components enable ubiquitous application. Importing these technologies will provide personalized learning opportunities. Context-aware ubiquitous learning emphasizes on context-aware learning environment. For traditional learning in the classroom, teachers teach students knowledge is unilateral. Because the teaching time is limited, traditional teaching is considered unable to enhance learning motivation and interest. It may result in the students' rote learning rather than absorption of knowledge and problem-solving ability (Brown, Collins, & Duguid, 1989). In the context-aware ubiquitous learning environment, teachers will guide the students to take the initiative to learn. It can attract their attention to enhance the learner's real-world observation and problem-solving skills. In addition, it is not limited in any time and at any place.

Radio Frequency Identification (RFID) was considered to be an important technology. Landt (2005) stored the unique identifier and data in the microchip RFID tags. When RFID readers and RFID tags emit radio waves after induction, it can complete a non-contact recognition process. In the context-aware ubiquitous learning environment, learning objects can be combined with RFID tags, and students can use RFID readers to learn on some mobile devices. Although the reliability and speed of recognition of RFID is high, most of smart phones and tablet PCs do not support RFID, and its total cost is more expensive than the other technology such as Quick Response Code (QR Code). Thus, QR Code is considered a candidate to replace RFID gradually in ubiquitous learning.

QR Code is a technology mainly used to store text data, and it provides the good fault-tolerant identification. Besides, the feature of low cost and easy to copy is the advantages (Hsu, 2010). Nevertheless, RFID and QR Code respond the information in time, but it is unable to be presented to blend virtual materials with the real environment. It is likely to result in the information inconsistency between reality and virtuality. Augmented reality (AR) is a technology that allows the presentation of the real world with virtual objects superimposed upon or composited with the real world. The virtual objects that can be used in AR include texts, images, 3D objects and other media. Students can get the related and coherent information immediately (Azuma, 1997).

2.3 The Advantages and Disadvantages of Augmented Reality

Bimber (2007) pointed out that the interactive digital technology has been applied in various fields widely, such that it can convey information through the real environment or objects with AR technology. Bimber (2007) designed an AR system in the museum's exhibition, users can observe dinosaur fossils

with head mounted display (HMD), and the system also provides a detailed description of the relevant parts. Wu, Li, Yao and Pai (2012) designed an AR-enhanced system combined with the physical and chemical experiments. Students can use cards to learn and experience from teaching materials, and interactive features such as experimental process operations. In addition, the system can reduce the risk of experiment. According to the mentioned application and analysis, an AR system needs a user interface which is friendly and easy to use. In addition, it can't hide the object in the reality and need to improve the speed of identification (Azuma, Bailiot, Behringer, Feiner, Julier, & MacIntyre, 2001).

2.4 *The Application of Augmented Reality in Language Teaching*

Kimer and Zorzal (2005) designed an alphabet-spelling game with AR technology. Among these spelling picture cards, students need to put the correct spelling picture cards together, and then the system will display the corresponding virtual object on screen. In this attractive environment, the system can enhance users' interaction and problem solving skills. Hsieh and Lin (2009) proposed an AR-enhanced English vocabulary learning system to achieve the effect of immersion learning. This system includes an English magic book which allows students to interact with. The system also provides many digital media and different stimulations of learning to students. The AR-enhanced English vocabulary learning system is able to be used by students to learn by themselves. Chang, Chen, Huang and Huang (2010) also used the AR technology to implement an English vocabulary learning system. To integrate the learning environment with game-based learning method in the proposed system, it enables no need of additional teaching materials and to promote the learner motivation. Tsai, Li and Wu (2011) proposed a Chinese learning system with AR technology. In the system, a lot of game cubes are provided, and each cube represents one Chinese character. When users combine Chinese cubes together to form a Chinese vocabulary, the explanation of the Chinese vocabulary will be displayed. Therefore, foreign learners can learn Chinese more easily with AR technology due to the instant interactivity.

AR technology is increasingly applied in various fields of studies. Because of the feature to allow the coexistence of virtuality and reality, it is expected to increase users' motivation and instant interactivity between user and system. Therefore, an interactive multi-language learning system enhanced by AR technology is developed in this study, and the advantage of the proposed system is to scan and focus simply the target object in real environment directly without any additional objects such as image cards. It is expected that this system can be used to stimulate students' learning motivation and enhance their learning effectiveness.

3. System Introduction

3.1 *Hardware Architecture*

Because an internal database is packed within the system, students can use a variety of mobile devices to launch the installed system instantly without Internet access as shown in Figure 1. All the students need to do is to scan the target objects, and then the corresponding virtual materials will be loaded and superimposed upon the screen. Therefore, students can interact with the AR-enhanced system to learn multiple languages.



Figure 1. The hardware architecture.

3.2 Software Architecture

The system is developed by the employment of Unity 3D game engine as the core and programming languages including JavaScript and C#. Open source software named Qualcomm AR (QCAR) is used to implement the augmented reality. Moreover, teaching materials are classified and imported into the corresponding databases such as text database, audio database, video database, and 3D model database.

3.3 Teaching Material

After discussion with teachers, totally 50 target objects provided by teachers are planned for this system as shown in Table 1.

Table 1: Target objects included in teaching materials.

Audio visual room	Auditorium	Basketball	Bulletin board
Black board	Chair	Chalk	Computer
Computer classroom	Counseling office	Desk	Dice
Door	Elevator	English classroom	Eraser
Faucet	Front gate	General affairs office	Glue
Guard room	Hallway	Health center	Hopscotch
Key	Library	Monkey bar	Music classroom
Parking lot	Playground	Principal office	Projector
Railing	Remote control	Ruler	Science classroom
Screen	See-saw	Sink	Slide
Stair (s)	Students affairs office	Studies affairs office	Swing
Television	Toilet	Trash can	Water
Window	Windowsill		

When students scan and focus on the target object through the system, they obtain corresponding learning contents including Mandarin, Hokkien and English as shown in Table 2.

Table 2: The presentation of teaching materials in the system.

Target Object	Mandarin	Hokkien	English	English Sentence
	桌子	toh-á	D.E.S.K. Desk	It is on the desk.

3.4 System Operation

The system is very easy to use. All the students need to do is to scan and focus on the target object with a mobile device such as a smart phone or a tablet PC as shown in Figure 2.



Figure 2. The operation to scan and focus on the target object with a mobile device.

After successful identification, it will display available buttons on the bottom of screen as shown in Figure 3. These buttons can be used to provide corresponding pronunciation in Mandarin, Hokkien, and English.



Figure 3. The screen presentation after successful identification of the target object.

If “Display” button is pressed, it will be toggled into “Hide” button, and all corresponding teaching materials for the target object including a Chinese vocabulary and an English vocabulary as well as an example of English sentence and its explanation in Chinese will be displayed on the screen as shown in Figure 4.

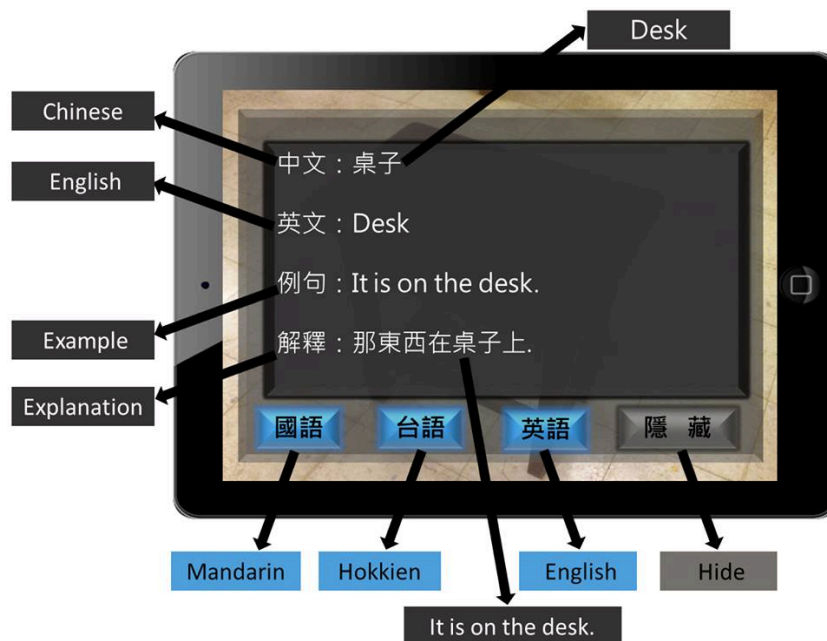


Figure 4. The screen presentation after “Display” button is pressed to toggle into “Hide” button.

As shown in Figure 5, there are three buttons (Mandarin button, Hokkien button, and English button) on the bottom of the screen. Each button provides a corresponding audio content. When “Mandarin” button is pressed by students, at first it will pronounce Mandarin Phonetic Symbols (MPS) one by one corresponding to individual characters of the Chinese vocabulary. Then, the whole Chinese vocabulary will be spoken in Mandarin, and the corresponding Chinese explanation will be spoken subsequently in Mandarin. When “Hokkien” button is pressed, the whole Chinese vocabulary will be spoken in Hokkien with Roman Pinyin, and then the corresponding Chinese explanation will be spoken at the same way. When “English” button is pressed, at first it will pronounce individual alphabets of the English vocabulary one by one in English. Then, the whole English vocabulary will be spoken in English, and the example of English sentence will be spoken subsequently. Students can repeat the audio content many times to enhance sensory stimulation and impression in the brain.

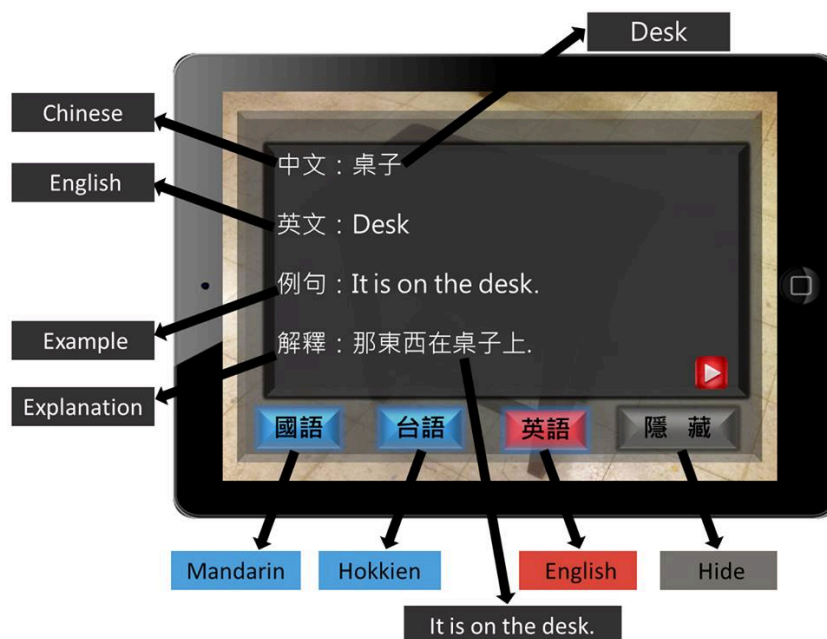


Figure 5. The screen presentation after “English” button is pressed.

4. Conclusion and Future Study

In this study, an interactive multi-language learning system with augmented reality is developed for an elementary school. Students can use the system to learn a Chinese vocabulary and its corresponding English vocabulary as well as its corresponding pronunciations including Mandarin, Hokkien, and English. The system also provides an example of English sentence and its corresponding Chinese explanation. The proposed system is expected to promote students' learning motivation and learning effectiveness by multiple sensory stimulations.

In the future, a teaching experiment will be implemented in September 2013, and the experimental subjects are students in an elementary school in Middle Taiwan. It is intended to explore the impact of students' learning style on their technology acceptance toward this system. Thus, in order to measure students' learning style, a questionnaire is designed according to the index of learning style proposed by Soloman and Felder (2001). In order to survey the technology acceptance of students toward this system, the important determinants in Technology Acceptance Model (TAM) proposed by Davis (1989) including perceived usefulness, perceived ease of use, attitude toward using, and behavioral intention to use, is applied to design a questionnaire. The experiment process is planned and illustrated as shown in Figure 6.

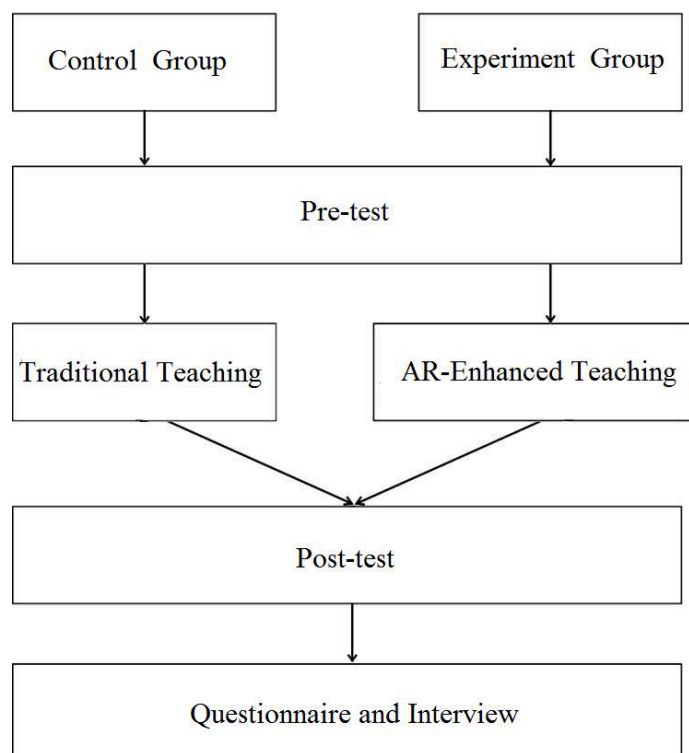


Figure 6. The experiment processes in the future study.

Acknowledgements

This study is sponsored by the National Science Council in Taiwan under the contract no. NSC102-2511-S-275 -003.

References

Azuma, R. (1997). A survey of augmented reality. *Presence: Teleoperators and Virtual Environments*. 6(4), 355-385.

- Azuma, R., Bailiot, Y., Behringer, R., Feiner, S., Julier, S., & MacIntyre, B. (2001). Recent advances in augmented reality. *Computer Graphics and Applications, IEEE*, 21(6), 34-47.
- Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, 18(1), 32-42.
- Bimber, O. (2007). *The reality of mixed reality*. Bauhaus-University Weimar.
- Chang, Y. J., Chen, C. H., Huang, W. T., & Huang, W. S. (2010, December). Application of augmented reality on implementation of the English vocabulary learning system. Paper presented at the 16th Conference on Information Management & Practice (IMP 2010), National Yunlin University of Science and Technology, Yunlin, Taiwan.
- Clark, J. M., & Paivio, A. (1991). Dual coding theory and education. *Educational Psychology Review*, 3(3), 149-210.
- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319-340.
- Hsieh, M. C., Lin, H. C. (2009, September). Employing augmented reality to promote English vocabulary learning. Paper presented at the 5th Taiwan E-Learning Forum (TWELF 2009), Tainan, Taiwan.
- Hsu, P. C. (2010). The applications of QR code in libraries. *Interdisciplinary Journal of Taiwan Library Administration*. 6(4), 95-103.
- Kimer, C., & Zorzal, E. R. (2005). *Educational applications of augmented reality collaborative environments*. Proceedings of sixteenth Brazilian Symposium on Informatics in Education, 114-124.
- Landt, J. (2005). The history of RFID. *IEEE Potentials*, 24(4), 8-11.
- Savignon, S. J. (1988). In second language acquisition/foreign language learning, nothing is more practical than a good theory. *Issues and Developments in English and Applied Linguistics (IDEAL)*, 3, 83-98.
- Soloman, B. A., & Felder, R. M. (2001). *Index of Learning Styles Questionnaire*. Retrieved from <http://www.engr.ncsu.edu/learningstyles/ilsweb.html>
- Tatar, D., Roschelle, J., Vahey, P., & Penuel, W. R. (2003). Handhelds to school: Lessons learned. *IEEE Computer*, 36(9), 30-37.
- Tsai, Y. S., Li, L. M., & Wu, A. H. (2011, November). Augmented reality applications in Chinese digital teaching materials: On Chinese cubes. Paper presented at the 7th Taiwan E-Learning Forum (TWELF 2011), Taipei, Taiwan.
- Wu, M. N., Li, M. H., Yao, Y. J., & Pai, T. F. (2012, October). Interactive digital teaching for chemistry experiment using. Paper presented at the 8th Taiwan E-Learning Forum (TWELF 2012), Tainan, Taiwan.

A Study of Pragmatics applied to Teacher – Parent Communication

*Ching-Feng CHEN^a, Cong-Xun XIE^a, Shein-Yung CHENG^a, Wen-Yi Zeng^a, Wei-Fu Huang^a & Jia-Sheng HEH^a

^a*Department of Information and Computer Engineering,
Chung Yuan Christian University, Taiwan*

*cloudly@cloudly.tw

Abstract: With progress society and increased information, parents cloud participate their children's learning become easier. And parents' educational backgrounds are increasing, so they have more and more different opinions on the method of disciplining their children by teacher in school. It is pressing that try to create a efficacious approach of teacher – parents (abbr. as T - P)communication, and how to cause parents participate their children's learning more willing, and how to cause parents interactive with teacher more active is a important question. This study researched the theory of the pragmatics and speech act theory, classified the dialogue between teacher and parents, used the method of association rules in data mining, tried to find a active module of T - P communication, to use helpful in general teaching placement, provide teacher to increase parents participate their children's learning. In this study, we found out 28 rules of association rules from the T - P dialogue on the student homebook in the last year, and checked these rules by the new T - P dialogue in this year. We found the precision form 40% to 100%, and the recall from 4.35% to 69.57%. The result shows the association rules is in line with the different T - P communication, it can be provided to teacher as reference. We proved if the association rules were true, teachers were not soliloquizing any more, and parents reply willing, T - P communication was frequently.

Keywords: *teacher – parent communication, speech act theory, association rules*

1. Introduction

1.1 Study background

There are situation in the traditional educational placement that parents send their children to school and are indifferent to their own children's learning. And teacher served the role of discipline resolutely, alone, closed as an ivory tower. But society is progress and open, information spread more and more convenient, and the universal of the national education promote the parents educational background, furthermore the government pursue the “opened education” policy that encourage parents in participating school affairs. Many parent's attitude on participating become positive from Indifference, and provided their opinions for teacher teaching method, teacher discipline method, school affairs.

Therefore, the basic ability teacher required establishes a good communication approach and makes an effective T - P communication. The specific method of teacher and parents included use the student homebook, class periodical, school Parents' day, telephone contacts, home visit, website, etc. In generally, the most common and most easily way to establish T - P communication is use the student homebook. Parents could understand their own children's learning at school by the contact matters teacher noted. And parents could put forward their opinion for children discipline on the homebook to make communication with teacher. Some teacher requires students recorded their own sport, homework, et cetera for improving student's character.

1.2 Motivation

The study cause parents to participate their own children's learning more activity understand children's requirement and provide it, known teacher teaching method and teacher discipline method, make effectible in T - P commutation. Make parents and teacher become student's suppliers on learning.

Use speech act theory and data mining, we expect find out effectible module of T - P communication. It could be referenced for teacher use to communicate with parents, not only make parents dialogue more activity, but also teacher and parents could share their ideas each other in intensive dialogue. Upgrade relationship between teacher and parents.

2. Problem Formulation

2.1 Teacher - parent communication

In the educational environment, parents participate in their own children's learning are more and more easy and important. Because of parents' attendance of school activities, open-school nights, and parent-teacher conferences, are related positively to elementary-school-aged children's learning performance (Becker & Epstein, 1982). And Cochran and Dean presented that if parent were empower will have positive impacts on T - P relationships and on children's school performance (Cochran & Dean, 1991). But from the different concept between teacher and parents in teaching and discipline student, it might be cause the mistake from each other. T - P communication was required in the classroom and family.

T - P communication is one of kind concept included in T - P interactive, and it's interwoven with "T - P cooperation" and "parent involvement". Communication is one of kind social mentally progress, and people share information, ideas, emotion with others through communicating each other. Teacher and parents always communicate in student affairs like (Tomlinson, 1996):

- How teacher and parents urge student make advances in learning.
- Explain the study progress in classroom.
- Question of student activity at school.
- Tell parents what they could do at home.
- Hold up the activity that could support student learning.
- Discuss the affairs of school and class it round the corner.
- Recruit volunteer to help school and class dispose chore about study.

Thus, T - P communication could help teacher in teaching affair and improve their own children learning. Teacher and parents communicate through any method to exchange opinions each other, understand concept both side, could be positive on student learning. It is important to create an efficient T - P communication with parents for teacher in their own class.

2.2 Pragmatics

Pragmatics is a functional overview of all aspects of the language, it researches acknowledge, social and culture of language in human life. From the perspective of the speaker, it researches meanings that speaker said, and researches how people use language to accomplish social intercourse. From the listener's point of view it, it research the different between people knows in social activity and in listening, and research people dedicate to reach agreement by language (George Yule, 1996).

Pragmatics could explain simple the study that researches some specific behaviors in human life. It not only includes content of dialogue, but includes purpose, deep thinking, etc... By combining several speech behaviors into a specific combination that language means.

The speech act theory could present as "speech is ding". If speakers said meaningful and listener could understand, the behavior could be called speech act (Austin, 1962). Austin presented the three layers of the speech act, when speak, we just implement the one of three speech act layers, the three layers as follow:

- Locutionary act: speaker said a sentence has specific meaning and point out someone, and listener could understand the behavior in the speech act.

- Illocutionary act: speaker implement specific social purpose and specific function through speech act.
- Perlocutionary act: listener were influenced from the speech aroused effect and result.

Searle think the speech act is “Illocutionary act”, all of the language that speaker said before sent purpose and objective through speech act (Searle, 1969). Searle has classified speech acts like this (Owen Eriksson, 1999):

- verdictives: the speech act of verdictives is to commit the speaker of the truth to the expressed proposition.
- exercitives: the speech act of exercitives is an attempt from the speaker to make the listener to perform an act.
- commissives: The speech act of commissives is that the speaker commits himself to perform an act.
- behabitives: The speech act of behabitives is to express the speakers psychological state about the state of affairs presented in the propositional content of the speech act.
- expositives: The speech act of expositives is that their successful performance guarantees that the propositional content of the speech act corresponds to the world. Declarations bring about alteration in the status of the referred objects. This feature distinguishes them from other classes.

The speech act theory will be used to analysis the dialogues on the student homebook in this study, those dialogue will be classified from the classification. From these dialogues, we expect the potential T – P communication model would be found. Following these model, T – P communication could be improved, T – P relation would be tied deeply.

3. Analysis

3.1 Analysis of study goal

Previous research reported that if teachers had effective communication with parents, the parents would promote their participation to help children learn, thus the teachers’ teaching skills could be improved, the parents’ educational knowledge could be increased, and the relationship between teachers and parents and school could be established. Many kinds of T – P communication methods can be applied, such as students’ homebooks, telephone, e-mail, home visit, and website. Amongst these T-P communications, students’ homebooks are the most general and the most convenient.

From T-P dialogs from real students’ homebooks, this study tries to analyze these conversations to look into the embedded regularities. Speech act theory in pragmatics is introduced and the association rules within the dialogs are then obtained. In order to find the application powers of the obtained association rules, their precisions and recalls will be calculated in a series of experiments. With careful check for the precisions and recalls of the association rules, a satisfactory T – P communication can be conveniently obtained and the T-P misunderstanding can be greatly decreased.

3.2 Process of study

In order to find the association rules in T – P communications, the dialogues between teacher and parents left last year in the student homebook were collected into files. then the dialogues were classified into 7 classifications we defined by speech act theory. The implicative association rules in these dialogues were found by using data mining theory with Apriori algorithm. The second step is to test and verify how the association rules fits to the actual teaching environment, so the degree of exactitude were check by using precisions and recalls.

In this step, the dialogues between teacher and parents left in the student homebook were collected again, but last semester, parents of the dialogues were different with the parents when association rules found. And use the same classification method to classify the dialogues into 7 types. Finally use the precisions and recalls calculation method to calculate the precisions and recalls value of each association rules.

The flow chart of total process of study is figure 1:

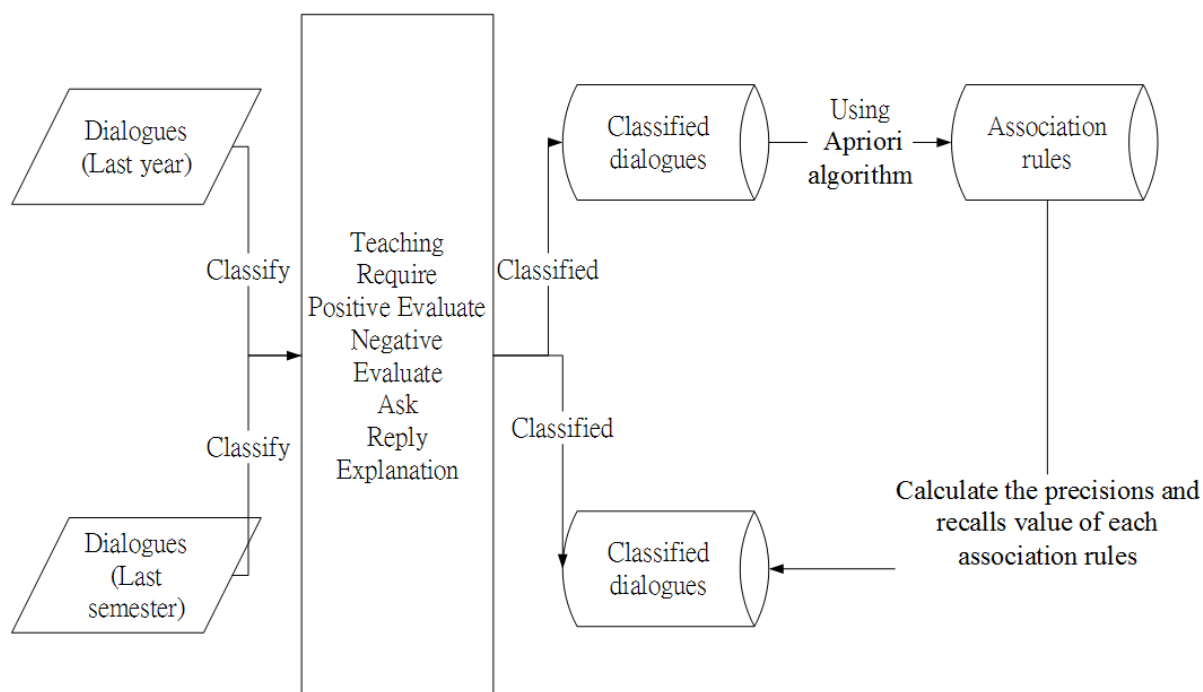


Figure 1. The flow chart of total process of study

3.3 Coding method

In chapter 2 shows the speech act theory has three layers: locutionary act; illocutionary act; perlocutionary act, the illocutionary act would be focused in this study. And Searle divide the illocutionary act into five types: verdictives; exercitives; commissives; behabitives; expositives. Bales research the conversation and divide the illocutionary act, too. And Hoope used finite state machine to divide the illocutionary act

The first step is to analysis the illocutionary act in T - P communication dialogue and classify it into several types, in order to understand the interactive of teacher and parents. From the represented theory by Searle, Bales and Hoope, seven types of illocutionary act in this study were be defined. Each classification represents a behavior of dialogue that teacher or parents used. And these classifications are different from each other scholar, the comparative statement shows in table 1:

Table 10 The different classification of this study and the other scholar's

Our classification	Searle's	Bales's	Hoppe's
Teaching	Exercitives	N/A	Assert Offer
Require			Request
Positive Evaluate	N/A	Positive	Evaluate
Negative Evaluate		Negative	
Ask	Exercitives	Question	Request
Reply	Commissives	N/A	Promise Accept
Explanation	Behabitives Expositives	Information	Inform

The illocutionary act could be analyzed in T - P communication dialogue and divide them into 7 types according to the classification above. Use the method of association rule to find rules with highly support and highly confidence

The approach and step were listed as follow:

- Collected 2 studentbooks and type into a file, the number of dialogues by teacher is 40, the number of dialogues by parent is 25, the number add up to 65.
- Arrange the data in table by date, users, and contents. All dialogues were sequenced by date and grouped the dialogues at the same time, in order to match the association rules we found.
- Use the classification and illocutionary act divide the dialogues to 7 types, if the illocutionary act of the dialogues was fuzzy, and we used the Chinese grammar to be an aid judgment. The classification of dialogues in table 2:

Table 11 The classification of dialogues

<u>classification of illocutionary act</u>	<u>Basis of classification</u>	<u>illocutionary act language</u>	<u>Example</u>
Teaching	Teacher and parents give guiding for student's learning, how to do and expect the performance they have.	是、還是、使、才能、才可、才是、才可以、如此才能、才不會、才不因、就不容易、愈...愈...、希望能、一定更佳、加油	多寬心才能事事順心，學習才可有更多空間！
Require	Teacher and parents require student to have some behavior, usually used when student had bad behavior	要、要多、要有、要確實、要認真、要懂得、要注意、要更努力、勿、不可、不要積累、不要草率、還要、需...、需把、仍需、需注意、也要、也不要、請注意、多看書、就趕快、盡責完成。	也不要只想著怎麼作比較快，要認真完成！
Positive Evaluate	Teacher and parents commend student for good learning behavior, by praise encourage student to have more excellent performance.	進步了、有盡責、有進步、能聽勸、會改進、會主動、很認真、錯誤較少、愈...愈好	※※有進步，能聽勸，會改進
Negative Evaluate	Teacher and parents blame student for bad learning behavior, hope student understand than change their mistake.	不用心、未確實、未完成、有點混、真的很愛	國習書寫不用心
Ask	Teacher and parents need support by each other used.	嗎？、為了什麼？、請※※、請老師、請家長、麻煩老師、麻煩媽媽、老師麻煩跟你拿、你要再、老師要跟你借	不瞭解請老師教導
Reply	Teacher and parents reply request by each other, but usually use "thanks" instead.	ok、謝謝、感恩、我會、瞭解、知道了、已收到	謝謝 OO 的體貼
Explanation	Teacher and parents explain status for student. This sentence include more situation especially the sentence include "cause and effect", but there are not "please" include.	故、但、且、像、因、由、將、仍、已、因為、但因、不過、只不過、所以、忘了、有為、如有、不如、好了、讓她、好感動、遇到了、未寫完、有提到、明天不上、無法參與、訂正完成、沒帶回來、明天不上	※※因為昨天人不舒服（頭痛想吐），所以功課還有一樣沒寫完

- d. For reaching the independence of association rules required, we classify the term just fit the classification.
- e. In addition to the classification, we distinguish the term between teacher and parents used by adding preposition as “T” and “P”, like “T- Teaching” or “P- Require”.

4. Design

4.1 Data mining and association rules

In order to assist human in extracting useful information (knowledge) from rapidly growing volumes of digital data, there is an urgent need for a new generation of computational theories and tools, those theories and tools are the subject of the emerging field of knowledge discovery in databases (KDD) (Fayyad, Piatetsky-Shapiro & Smyth, 1997). Data mining is one of the analysis steps of the KDD.

Data mining is the nontrivial extraction of implicit, previously unknown, and potentially useful information from data (Frawley, Piatetsky-Shapiro & Matheus, 1992). And Data mining is the analysis of (often large) observational data sets to find unsuspected relationships and to summarize the data in novel ways that are both understandable and useful to the data owner (Hand, Mannila & Smyth, 2001). Data mining generally use six common classes of tasks to excavate the potentially information. The six tasks is Anomaly detection, Association rule, Clustering, Classification, Regression, Summarization, Sequential pattern mining.

In this study, the Association rules were used to find the potential communication model. Association rules are found from a large database, all of the rules are presented interesting relations between variables. It is intended to identify strong rules discovered in databases using different measures of interestingness (Piatetsky-Shapiro, 1991). Such information can be used as the basis for decisions about marketing activities such as, e.g., promotional pricing or product placements.

For example, there is a set I contain three items X, Y, Z, the set {X, Y} is the subset of I, and the set {Z} is the subset of I too. There is an association rule that {X, Y} → {Z}, the set of items X and Y are called antecedent (left-hand-side or LHS) and consequent (right-hand-side or RHS) of the rule respectively. The association rule means if item X and item Y are found, the item Z would found too. Before analysis, the minimum support and minimum confidence were be set up, the support is the ratio of items of association rule to the data, the confidence is the ratio of the RHS of association rule to the LHS in the data. The association rules are effective when the support and confidence of association rules are over than the minimum support and minimum confidence.

In association rule, there a best – known algorithm to mine association rules, it is Apriori algorithm. In this study, Apriori algorithm was used to find the association rules in T – P dialogue data. It is used in finding the maximum item set in the data by identifying the frequent individual items and extending them to larger and larger item sets as long as those item sets appear sufficiently in the data.

4.2 Finding association rules

In finding association rules we should set parameter for minimum support and minimum confidence, we set the minimum support as “11.90%” and minimum confidence as “50%”. In Taiwan, parents’ works becalmed double-income families from single- income families so that parents sent their children to daycare and reduce the careful degree. Parents make the communication with teacher weakly. To avoid there were not any association rule be found, so the minimum support were set as “11.90%” by experiment several times.

There were total 28 association rules founded as table 3:

Table 12 The association rules

Association rule				Support (%)	Confidence (%)
Antecedent item set			Consequent item		
1	P-Ask	T-Reply	→ P-Reply	14.29	50.00
2	P-Explanation	P-Ask T-Reply	→ P-Reply	11.90	60.00
3	P-Explanation	T-Reply	→ P-Reply	14.29	50.00
4	T-Teaching	T-Require	→ P-Reply	16.67	57.14

5	T-Explanation	→ P-Reply	28.57	50.00
6	P-Explanation T-Reply	→ P-Ask	14.29	83.33
7	T-Reply P-Reply	→ P-Ask	11.90	60.00
8	T-Reply	→ P-Ask	26.19	54.55
9	P-Ask T-Reply	→ P-Explanation	14.29	83.33
10	T-Reply P-Reply	→ P-Explanation	11.90	60.00
11	T-Reply	→ P-Explanation	26.19	54.55

In order to check does it fit the actual teaching environment, there were several experiment could be used to check it.

- Collect several student homebook that was used in last semester, there were integral dialogue by teacher and parents. By the classification classify the dialogue and compare with the association rules to check its confidence.
- Experiment actually with student and parents, teacher send the dialogue based on association rules to check does the dialogue by parents fit the association rules or not.

The experiment A was used to check the confidence of association rules because the data of whole class students are more complete than experiment B. The dialogues are more real and fit the actual teacher and T - P communication.

4.3 Precision and recall

The “Precision” and “Recall” were used to check the confidence of association rules. The meaning of “Precision” is the fraction of retrieved instances that are relevant, and the meaning of “Recall” is the fraction of relevant instances that are retrieved.

In the field of this study, “Precision” is the fraction of item set in the association rules that matched to the experiment data:

$$\text{Precision} = \frac{\text{The number of the association rule found}}{\text{The number of the antecedent item set found}}$$

In the field of this study, “Recall” is the fraction of consequent item in the association rules that matched to the experiment data:

$$\text{Recall} = \frac{\text{The number of the association rule found}}{\text{The number of the consequent item found}}$$

5. Experiment & Discussion

5.1 Experiment environment

The experiment data came from a school that placed at remote country in New-Taipei city. The amount of student in a class were just 16, there are 9 boys and 7 girls. Their parents almost works in factory as an office worker, works in their own farm as a farmer and stay home take care their children as a housewife. Parents’ educational backgrounds were lower than the parents lived in city. But parents care for their own children well, and replied the notes teacher left actively.

In the class, there 2 students are more special than the other students, they are served special education. One of them, parents take care student actively more than other parents, interact with teacher on student homebook and using telephone. The other one parent were restricted by her education environment and body defect, so they cloud not care for their own children as the other parents, but they take care as well.

The totally student homebooks were collected to check the precision and recall, all of the dialogues on them were typed into files as when the resource data of association rules collected. Then the dialogues were classified into 7 types by the same classification that were defined before. The illocutionary speech acts were listed by each dialogue sheets.

5.2 Experiment step

The illocutionary speech act of teacher and parents were compared with the association rules to calculate the value of precision and recall, the result is table 4:

Table 13 The result of the precision and recall

Antecedent item set			Consequent item	Precision (%)	Recall (%)
1	T-Reply	P-Ask	→ P-Reply	40	17.39
2	T-Reply	P-Explanation P-Ask	→ P-Reply	42.86	13.04
3	T-Reply	P-Explanation	→ P-Reply	45.45	21.74
4	T-Teaching	T-Require	→ P-Reply	50	4.35
5	T-Explanation		→ P-Reply	69.57	69.57
6	T-Reply	P-Explanation	→ P-Ask	63.64	43.75
7	T-Reply	P-Reply	→ P-Ask	57.14	25
8	T-Reply		→ P-Ask	66.67	62.5
9	T-Reply	P-Ask	→ P-Explanation	70	29.17
10	T-Reply	P-Reply	→ P-Explanation	71.43	20.83
11	T-Reply		→ P-Explanation	73.33	45.83

5.3 Discuss

From the result of the precision and recall, the values of precision is from 40% to 73.33% that proved the association rules is fit to the actual T – P communication in educational environments. If teacher communicate with parents and follow the association rules, it would be expect that parents will active in replying and communicate with teacher happily. From the communication, the good relation of teacher with parents will be built, and teacher and parents will be partner cooperation in student's learning.

Teacher could leave messages with the antecedent item set of association rules for increasing the dialogue sheet when communicated. For example, the rule No.5 it would own highly Precision and Recall, when teacher use the speech act "T-Explanation" to explanation affairs about student, it could be predictable that parents would reply with the speech act "P-Reply". And teacher could follow the rule No.7 or No.10 to reply with the speech act "T-Reply" to reply, perhaps parents will reply with the association rules, thus the communication could be modified and improved.

The values of recall are from 4.35% to 69.57% that shows parents replied monotonously and used the same speech act frequently. The type of speech act "P-Reply" were used almost in the communications. One of the reasons perhaps that Chinese talks with high politeness, parents replied with politeness language like "thanks". The other one reason that parents replied with meaning of understanding, when teacher taught student and informed parents, parents replied language like "yes" or "I know" to present their understanding. Teacher could try to use more speech act or another speech act word to cause parents to reply with more different speech act types.

6. Conclusion

6.1 Summary

Many method were put forward to improve the frequently of T – P communication, promote the relation between teacher and parents, to make high performance on student's study. The method were presented in this study that use Pragmatics theory and Association rules to find some potential rules in T – P communications, create a model fit to the generally T – P communications. In this model, it shows the frequently communication of T – P speech act theory, it could be referenced to teacher use in T – P communication.

The association rules found in this study could help teacher to create a high frequency when communicate with parents because of the high precision in the result of this experiment. When the communication contains these association rules, teacher would not soliloquize anymore, and parents would reply the communication more willing. They could discuss the opinion in their student's education method and how to bring up their student.

But it shows that when parents replied were pure and monotonous, so that the reply always belong to the classification of Reply with polite formula. So it could be the future works that teacher how to encourage parents to participate in different kind communications.

6.2 Future Works

In this study, the association rules have several items as follows were restricted by environment could not experiment, expect them could be strengthened in the future work.

- The amount of experiment data could be increased: this study just only has 16 students when the experiment proceeds because of the school were located in a remote place, so the experiment data were few there. Not only looking for the association rule were restricted, but also the careful check for the precisions/recalls of the association rules were influenced.
- The collection of experiment data could be easier: in this study the paper student homebook were used to collect all of the data, but it wasted time so much. If the internet student homebook could be used in experiment to collect the data, the procedure of typing words into files could be skipped over. And we could use association rules to all of parents to implement the effect at once.

References

- Fayyad, U., Piatetsky-Shapiro, G., & Smyth, P. (1996). From Data Mining to Knowledge Discovery in Databases. *American Association for Artificial Intelligence*, 17(3), 37-54.
- William J. Frawley, Gregory Piatetsky-Shapiro & Christopher J. Matheus. (1992). Knowledge Discovery in Databases: An Overview. *AI Magazine*, 13(3), 57-70.
- Hand, D., Mannila, H., & Smyth, P. (2001). Principles of Data Mining.
- Piatetsky-Shapiro, G. (1991). Discovery, analysis, and presentation of strong rules. *Knowledge Discovery in Databases*, AAAI Press, 229-248
- Cochran, M., & Dean, C. (1991). Home-school relations and the empowerment process. *The Elementary School Journal*, 91(3), 261-269.
- Becker, H. J., & Epstein, J. L. (1982). Parent involvement: A study of teacher practices. *The Elementary School Journal*, 83(2), 85-102
- Tomlinson, S. G. (1996). Welcoming parents at your school: Strategies that work. *Office of Educational Research and Improvement (ED)*, Washington, DC. *ERIC Document Reproduction Service No. ED404703*.
- George Yule. (1996). Pragmatics. *Oxford University Press, Oxford*.
- Austin, J.L. (1962). How to Do Things with Words. *Oxford University Press, Oxford*.
- Searle, J. R. (1969). Speech Acts - an Essay in the Philosophy of Language. *Cambridge University Press, London*, pp.203.
- Eriksson, O. (1999). A generic communication model based on Habermas and Searle's versions of Speech act Theory. *Proceedings of the fourth International Workshop on the Language Action Perspective on Communication Modelling (LAP'99)*, Copenhagen, September 12-13, 43-58.

Enhancing Learning Achievement Using Affective Tutoring System in Accounting

Ya-Ping HSUEH, Hao-Chiang Koong LIN & Meng-Shian OU*

Department of Information of learning technology, National University of Tainan, Taiwan

*markoms2000@Hotmail.com

Abstract: This paper shows an affective tutoring system which enforces accounting remedial course and hopes to be useful for student's learning achievements. In order to make the low-achievement students to be more willing to learn, there are more and more colleges implementing the remedial education to promote student's learning achievements. Because of the innovation of technology, computer becomes a main tool for e-learning. Besides study and work, there are more and more computer's developments of the interaction with people. For example, there are some studies about making computer to perceive human's emotions, express emotions and feedbacks in time. Recently, many studies also show evidences that the emotions is an important factor to affect learning.

Our participants are some low-achievement students who are freshmen in Taiwan. We try to know the usability of the affective tutoring system using in accounting remedial course for learners. We also want to realize whether the accounting remedial course using affective tutoring system affect the learning achievements and motivations. We adapt observational survey in the experiment and make a learning achievement questionnaire at the end on experiment. The questionnaire contains learning achievements, system's usability, and learning motivation. We also implement focus group to get some feedback and quantitative data to analyze with statistical software. In conclusions, we find learner have good usability and satisfaction at using affective tutoring system to do accounting remedial course. The tutoring agent also has the benefit to enhance learner's learning motivation. The value of learning achievement is 0.93 and is highly significant.

Keywords: Affective tutoring system, remedial education, learning achievement, affective computing, accounting.

1. Introduction

Computer has become a necessary tool for lots people in their lives. More and more digital applications are developed for work, leisure, and study. When human-and-computer interactions are taken into consideration in the design of both hardware and software, computers are no longer a machine but human-like existence. Therefore, some studies focus on how to increase the interactions between people and computer, how to make the computers to perceive human emotions, and even how to make computers express emotional responses immediately. For example, the Ph. Picard's team of MIT media lab is devoted to the field of Affective Computing and has many outcomes.

"Affective Computing" means to obtain some face-emotion and physiological signals which are triggered for human feelings through different sensors and to analyze these signals to provide suitable replies or feedbacks (Manovich, 2001). Affective computing is a study on emotion perception, the establishment of proper emotion-models, and the expression and transmission of emotions by ways such as the Internet (MIT Media Lab, 2008). Recently, the affective computing has been applied to different fields such as education learning, multimedia processing, and human-machine interface (HMI). Hupont, Abadía, Baldassarri, Cerezo and Del-Hoyo (2012) designed a tool-T-EDUCO which can detect the emotions of people. In order to enhance student's learning achievements, teachers can use it not only to get some messages of students' academic or emotion states, but also to detect students' learning progresses and to provide them proper teaching strategies and learning information when needed.

Accounting is not an easy subject to learn so that students usually have some difficulties to learn. For example, we can realize student's learning status from their accounting grade. If students do not learn well, they will be low patient in learning. In order to help those students who do not learn well, schools implement strategies such as teaching assistants, teacher's office hours, and on-line remedial courses. However, some students resist to face teachers in person so this research plan to make distance remedial course.

There are many reasons affecting learning such as emotion; for example, positive emotion will promote learning motivation but negative emotion will not. So if we can realize learner's emotion when they learn, we will have more ways to help them. Affective Tutoring System combines Intelligent Tutoring System and emotion recognition mechanism. With Affective Tutoring System, learners can take the remedial course by themselves and the affective tutor can detect learner's emotions to give them proper feedbacks for promoting their learning motivations.

This paper presents the design and development of an affective tutoring system for the accounting class. A virtual tutor would recognize the students' emotions and give feedbacks in time. Affective Tutoring System (ATS) inspires students' learning motivations in the process of interacting with the virtual tutor and provide students with proper course materials to enhance learning achievements. The research uses questionnaires to investigate students' satisfactions to ATS and to evaluate the usability of ATS.

This work focus on following problem: (1) Does it have good usability when add accounting course to ATS? (2) Are there significant differences in learning motivations when learners use ATS to learn the accounting course? (3) Are there significant differences in learning achievements when learners use ATS to learn the accounting course.

2. Literature Review

2.1 Affective Computing

Affective Computing means that we give computer the ability to recognize, express, have emotion and emotional intelligence. Most of studies focus on the field recognizing emotion and expressing emotion (Picard & Klein, 2002). Affective Computing also tries to know human's emotion which how to trigger or what can it affect. Picard's study team has ever tried hard to make a computer program that has ability to recognize emotion, transmit human's emotion and do some proper feedback.

2.2 Intelligent Tutoring System

Intelligent Tutoring Systems (ITS) means that computers are used to analyze, feedback, and provide individual teaching to students. Intelligent Tutoring Systems also can simulate real tutors to implement different teaching and provide student adaptive teaching methods based on his/her personality and situation. There are four parts of Intelligent Tutoring Systems as following: interface, expert, student and tutor mode (Koedinger & Corbett, 2006).

2.3 Affective Tutoring System

Kort et al. (2001) brought up a new model to conceptualize what affect learning emotion and create a model based on computer to recognize learner's emotion status, give proper feedbacks, and make learners learn in best status. Affective Tutoring Systems (ATS) means to add Affective Computing to Intelligent Tutoring Systems (ITS) so that it can make virtual tutor to have abilities to recognize learner's emotion in learning, adapt learner's emotion status, give proper feedbacks and arouse learners' learning motivations. Affective Tutoring Systems refer to computers that work like a real human to effectively adapt students' emotion status (Sarrafzadeh et al., 2003; Sarrafzadeh et al., 2004).

2.4 Remedial Education

Remedial education is multiple according to teacher's ideas, student's need and equipment in learning. There are some usual types used in teaching course such as compensatory program, tutorial program, adaptive program, supplemental program, basic skills program, learning strategies training program. In our work, we apply supplemental program and basic skills program to design our accounting course.

Supplemental program provides some extra knowledge which is not available in normal course but important for students. For example, we can provide low-achievement students some supplemental program.

Basic skills program focus on some basic skills which students cannot learn on normal course. Basic skills program believe that learning is a linear progress and students should learn progressively all course under basic knowledge; for example, if the students of sixth grade only have the written ability of third grade, the remedial course should adapt written abilities of third grade to enhance their skills. For the reason, we should find student's learning difficulties and know student's level of education and abilities.

3. Experimental Design

This work focuses on those students who have low-achievement in accounting. We take the midterm score as pretest. The experiment lasted 80 minutes approximately and 10 minutes for expert explanation. Figure 1 shows the experiment process that learners used affective tutoring system to have the remedial course about accounting and took the post-test for learning achievement, questionnaires of learning motivations and system usability about 20 minutes in the system. Finally, conduct the Focus Group interview and analyze the results from the post-test.



Figure 1. Research Environment

3.1 Participants and Environment

Forty five college students with commerce background were recruited to participate our experiment cause their low achievement in accounting course.

The experiment took place in a multimedia computer classroom. For each participant, we provided a computer with Internet connected and had installed the Affective Tutoring System, 19-inch monitor and 13 million pixels webcam.

3.2 System Structure

This work bases on two main topics: Affective Computing and Teaching. We divided into four modules: emotion recognition, tutoring agent, accounting course and teaching strategy.

(1) Emotion recognition module:

It has two parts: facial recognition and word recognition. Facial recognition uses webcam to capture learner's face and detects his/her facial emotion status. Word recognition allows user to enter

his/her learning status or mood for realizing learner's emotion. The ATS would adjust proper teaching strategies for the learners by the results above. Figure 2 shows the emotion recognition module.



Figure 2. Emotion Recognition Module

(2) Teaching agent module:

Like a bridge between the Affective Tutoring System and learners. Through the agent, we can inform the learners about the status and movements of the system, and we also can get learners' emotion status and care about what they need and provide proper feedbacks to help adjusting the teaching strategies for enhancing learners' learning motivation. During learning, the tutoring agent will provide some indications for learners to go on when they finish their current step or meet the end of the course. Tutoring agent has six facial feedbacks such as joyful, sad, confused, angry, boring and normal. Figure 3 shows the tutoring agent feedbacks.

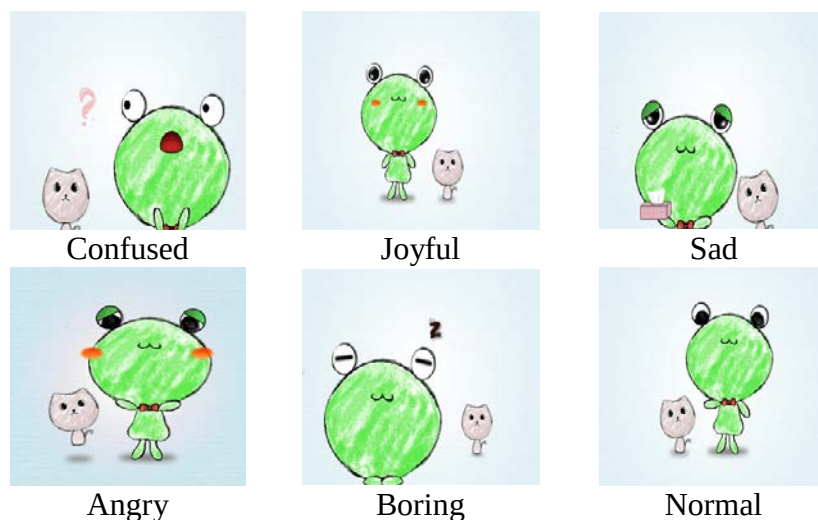


Figure 3. Tutoring Agent Feedbacks

(3) Accounting course module:

The accounting course was adapted from the first two chapters of IFRS Accounting (8e) about theory description.

(4) Teaching strategy module:

Many learners usually feel bored when they were learning digital course no matter what media it present (Greenagel, 2002). When learners come into negative emotion, it will affect learner's motivation, pleasure, and achievement. So we should add some interesting elements to transfer students' negative emotion and encourage students to learn when we are designing a digital course (Brown & Voltz, 2005).

Therefore, our system provides learners different learning contents according to learners' emotions. In order to enhance learners' learning motivation and learning achievements, the tutoring agent will detects learners' emotion at any moment by emotion recognition module. The tutoring agent will change the current course into a more interesting one when learners start appearing some negative emotions, and when the learners recover from negative emotions, the tutoring agent will change back the former course for the learners to continue learning.

4. Evaluation

4.1 Learning Effectiveness of ATS

For the evaluation, we quantified the 45 participants' pretest and posttest scores using descriptive statistics and paired-sample t-tests for data analysis. We also used Cohen's d for effect size. Based on Cohen's standard, $d=0.2$ was small, $d=0.5$ was moderate, and $d=0.8$ was large.

Table 1 shows the analyzed results of the learning achievements of accounting remedial course using affective tutoring system. The results show a significant difference between pretest and posttest ($p<0.001$ and $d>0.8$). We are confident for this experiment that the affective tutoring system used in accounting remedial course has a good effect for promoting learning achievements.

Table 1: Learning effectiveness analysis of ATS

	Sample	Mean	SD	t value	p	d
Pre-test	45	59.36	28.67	-7.006	0.000***	0.93***
Pro-test	45	78.78	12.93			

*** = $p<0.001$

4.2 Learning Effectiveness of Usability

In order to understand the relationship between learning achievements and the usability of affective tutoring system, Pearson correlation coefficient was used as show as Table 2. The results show negative correlations between learning achievements and system usability.

Table 2: Learning effectiveness analysis of Usability

	Sample	Signification (two-pair)	Pearson relation
Pre-test	45		1
Pro-test	45	.000	.868

5. Conclusion

This paper shows an affective tutoring system that allows users to do accounting remedial course and enhance learning achievement effectively. Our affective tutoring system uses facial emotion recognition and word emotion recognition to know learners' emotions in learning process. Positive emotions will promote learning motivations and negative emotions is on the contrary (Eyharabide et al, 2011). In order to change learner's negative emotions, tutoring agent offer signals for the teachers to make adjustments of their teaching strategies such as providing interesting content.

References

- Brown, A. R., & Voltz, B. D. (2005). Elements of Effective eLearning Design. *The International Review of Research in Open and Distance Learning*, 6(1). Retrieved May 13, 2008, from the Washington State University database.
- Eyharabide, V., Amandi, A., Courgeon, M., Clavel, C., Zakaria, C., & Martin, J. C. (2011, April). An ontology for predicting students' emotions during a quiz. Comparison with self-reported emotions. In *Affective Computational Intelligence (WACI), 2011 IEEE Workshop on* (pp. 1-8). IEEE.
- Greenagel, F. L. (2002). The illusion of e-learning: why we're missing out on the promise of technology. Retrieved in July 1, 2007 from <http://www.guidedlearning.com/illusions.pdf>.
- Hupont, I., Abadía, D., Baldassarri, S., Cerezo, E., & Del-Hoyo, R. A. F. A. E. L. (2011). T-EDUCO: A T-learning Tutoring Tool that Cares. *International Journal on Artificial Intelligence Tools*, 20(4), 639-661. (DOI: 10.1142/S0218213011000383)
- J. S. Wu (2010). IFRS: accounting Principles [Dictionary of the Chinese language] (8nded.). Taipei, Taiwan: Hwa-Tai publishing.
- Klein, J., Moon, Y., & Picard, R. W. (2002). This computer responds to user frustration: Theory, design, and results. *Interacting with computers*, 14(2), 119-140.
- Kort, B., Reilly, R., & Picard, R. W. (2001). An affective model of interplay between emotions and learning: Reengineering educational pedagogy-building a learning companion. In *Advanced Learning Technologies, 2001. Proceedings. IEEE International Conference on* (pp. 43-46). IEEE.
- Manovich, Lev. (2001). *The Language of New Media*, Massachusetts: MIT Press. Boston, Ma, USA: Spotlight on Works in Progress.
- Sarrafzadeh, A. (2002). Representing domain knowledge structure in Intelligent Tutoring Systems. *Proceeding of the International Conference on Information and Communication Technologies in Education*, 2,665-9.
- V. Eyharabide, A. Amandi, M. Courgeon, C. Clavel, C. Zakaria, J. Martin, "An ontology for predicting students' emotions during a quiz. Comparison with self-reported emotions", *Affective Computational Intelligence (WACI), 2011 IEEE Workshop on*, 11-15 April 2011, pp. 1-8

Evaluating the users' continuance intention and learning achievement toward augmented reality e-learning with user experience perspective

Yu-Ling LIU^a, Po-Yin CHANG^b & Chien-Hung LIU^{c*}

^a*Strait Chenggong Institute, Wuyi University, China*

^b*Department of Information Management, National Sun Yat-sen University, Taiwan*

^c*Department of Network Multimedia Design, Hsing Kuo University of Management, Taiwan*

*chliu@mail.hku.edu.tw

Abstract:

Nevertheless Augmented Reality (AR) has been applied to various e-learning systems, the study related to learning achievement and discontinue using anomalies are still insufficient, former meaning learner's learning achievement may decline with AR e-learning system, the latter denotes learner discontinue using e-learning after initially accepting it. Emerging design approach: User eXperience Design (UXD) could provide learner with great user experience to alleviate the above issues. This paper synthesizes the Information System Success Model (ISSM) and the Expectation-Confirmation Model (ECM) to established an extension model based-on user experience perspective to discovery what critical factors affected the users' learning achievement and users' intentions to continue using e-learning. Preliminary results of this study have shown our questionnaire reached good convergent and discriminate validities. In next steps, the model will be empirically tested with e-learning through various AR designed courses.

Keywords: augmented reality, e-learning, expectation-confirmation model, information system success model, user experience design

1. Introduction

E-learning has been attracted a lot of interest among academics and practitioners from the mid-2000s. Owing flexible and economic benefits, e-learning has attracted the attention of users and developers. Augmented Reality (AR) as a technology adopted to construct a three dimensional (3D) object of vocabulary (Fred D Davis, 1989; Fishbein & Ajzen, 1975; Gefen & Straub, 1997). Recently, integrating e-learning system with AR is a promising research direction in the education fields; however, most studies aimed on the adoption of AR learning system (ARLS) rather than the learning anomaly phenomenon.

The learning anomaly phenomenon often occurs when learner learning through ARLS. The anomalies may be roughly divided into two parts: learning achievement inconsistency and discontinue using intention. Former implies learners' learning achievement may decline when they are learning through AR, latter means that learner discontinue using e-learning after initially accepting it. Emerging design approach: User eXperience Design (UXD) may alleviate the above issues, because the well-designed AR courses with UXD may provide learner with greater user experience, and then improving the learner's learning achievement and continued intention to use ARLS. Thus, based-on user experience perspective, this paper proposed an extension-model which synthesized the information system success model (ISSM) and the expectation-confirmation model (ECM) to discovery what critical factors affected the users' learning achievement and users' intentions to continue using e-learning.

In section 2, we review previous ISSM and ECT, and modify them by integrating characteristics of ARLS. The research methodology and the instrument of questionnaire are introduced in section 3; section 4 contains discussions about preliminary results. Finally, the contribution and future research are concluded in final section.

2. Research Model and Hypotheses

Pervious study Nirit (Yuviler-Gavish, Yechiam, & Kallai, 2011) indicated that learner's learning achievement were inconsistent while they learning through multimodal training, the results of the study suggested that the abundant use of multimodal training in AR applications should be re-evaluated. We suggest that UXD may alleviate the problem, the results of Baird (Baird & Fisher, 2005) have shown that integrating user experience design strategies, social networking and other media can support neomillennial learning styles, promote the formation of learning communities, improve student engagement and reflection. Müller (Müller, Law, & Strohmeier, 2010) evaluate a set of theory-grounded User Experience (UX)-related measures, the results of the study appear UX-related problem areas anchored in the DeLone and McLean's ISSM (W. DeLone, 2003) had a consistently higher level of perceived persuasiveness than those anchored in the TAM (F.D. Davis, 1985).

According to the identified determinants for system success and continued intention, based on the updated ISSM of DeLone (W. H. DeLone & McLean, 2003) and ECM of Bhattacharjee (Anol Bhattacharjee, 2001), we propose an extension-model named Extension-ISSM (EISSM) in Figure 1 as our research model.

2.1 *The information system success model (ISSM)*

DeLone and McLean (W. H. DeLone & McLean, 2003) hypothesize that the greater the information quality, system quality, and service quality, get more individual net benefit, ISSM model is presented in the top parts of our research model as Figure 1. At a common level, there is considerable empirical research supporting the influence of system quality on IS Use (ARLS use in this study). The technology acceptance model (TAM) (F. D. Davis, Bagozzi, & Warshaw, 1989) predicts that perceived ease and usefulness, two key aspects of system quality (W. H. DeLone & McLean, 1992), have significant effects on attitude then cause information system (IS) use. Previous research has shown that information quality and system quality influences IS use suggested by (Igbaria, 1990). Moreover, Pitt et al.'s research (Pitt, Watson, & Kavan, 1995) as well as DeLone and McLean's model (W. H. DeLone & McLean, 2003) indicated that service quality and system quality influence IS use. These relationships may also be applicable within the ARLS context. Therefore, three hypotheses were established as below:

- H1: Information quality is positively related to ARLS use.
- H2: System quality is positively related to ARLS use.
- H3: Service quality is positively related to ARLS use.

In DeLone and McLean updated model (W. H. DeLone & McLean, 2003) which assumes that system quality, information quality, and service quality, both individually and jointly, affect user satisfaction and use. The model also suggests user satisfaction and uses to be reciprocally interdependent, and presumes them to be direct antecedents of individual impact. These relationships may also be applicable within the ARLS context; thus, five hypotheses were established as below:

- H4: Information quality is positively related to user satisfaction with ARLS.
- H5: System quality is positively related to user satisfaction with ARLS.
- H6: Service quality is positively related to user satisfaction with ARLS.
- H7: ARLS use is positively related to User satisfaction
- H8: User satisfaction is positively related to ARLS

Regarding individual net benefits, DeLone and McLean (W. H. DeLone & McLean, 2003) explained that net benefits (i.e., impacts) are measured in terms of job and decision-making performance. Individual net benefits measure the results of IS usage, according to DeLone and McLean (W. H. DeLone & McLean, 2003), certain net benefits will occur as a result of IS usage and IS user satisfaction. In general terms, it can be argued that if the user is satisfied with the IS, the IS will have an impact on the user's performance. In e-learning system, user satisfied with the IS will get greater

performance. Thus, individual net benefits which denote individual learning achievement in this study. This relationship may also be applicable within the ARLS context. Hence, we hypothesize:

H9: ARLS use is positively related to individual learning achievement.

2.2 Expectation–confirmation model (ECM)

Expectation–confirmation model (ECM) was proposed by Bhattacherjee (Anol Bhattacherjee, 2001), which for explaining IT continuance behavior based on the congruence between individuals' continued IT usage decisions and consumers' repeat purchase decisions. The model consists of four constructs: expectations, perceived usefulness, confirmation, and user satisfaction. The ECM anticipated that an individual's intention to continue IT usage is dependent on: the user's level of satisfaction with the IT; the extent of user's confirmation of expectations; and post-adoption expectations, in the form of perceived usefulness.

The bottom part of Figure 1 presents the ECM model. There are five main hypotheses in the ECM. First, users' satisfaction with IT has a positive effect on their intention to continue using the IT. Some marketing studies have explored that the primary reason explain why a consumer's decision to repurchase products or patronize services is their level of satisfaction, e.g. (Bearden & Teel, 1983; Oliver, 1993; Szymanski & Henard, 2001). For continued usage of IT products/services in a consumer context, there is some similarity between re-purchasing products or services. The ECM assumes an equivalent relationship in the latter context. In turn, user's satisfaction with IT is determined by the user's confirmation of expectations and their perceived usefulness of IT (which is one type of post-adoption expectation). The confirmation of expectations suggests that users obtained expected benefits through their usage experiences with the IT, and thus leads to a positive effect on users' satisfaction. On the other hand, based on the expectancy-confirmation paradigm, users' perceived usefulness of IT has a positive effect on their satisfaction with IT by working as a baseline for reference against confirmation judgments. This relationship is supported by the adaptation level theory, which proposes that users perceive stimuli only in relation to an adapted level. Prior marketing studies have found that the higher the users' expectations, the higher are their satisfaction (Oliver & DeSarbo, 1988). Moreover, previous IT adoption studies has consistently recognized that perceived usefulness is the most important determinant of users' adoption intentions (F. D. Davis, et al., 1989; S. Taylor & P. Todd, 1995; S. Taylor & P. A. Todd, 1995; Venkatesh, 2000). As a result, the ECM assumes users' perceived usefulness of IT has a positive effect on their intention to continue IT usage. Finally, the ECM assumes the confirmation construct will have a positive effect perceived usefulness of IT, causes perceived usefulness of IT be adjusted by confirmation contrast. (Anol Bhattacherjee, 2001; A. Bhattacherjee, 2001). Because e-learning is a kind of information technology on the Internet, we hypothesize:

H10: Perceived usefulness is positively related to User satisfaction.

H11: Confirmation is positively related to User satisfaction.

H12: Confirmation is positively related to Perceived usefulness.

H13: User satisfaction is positively related to individual learning achievement.

H14: User satisfaction is positively related to continued intention.

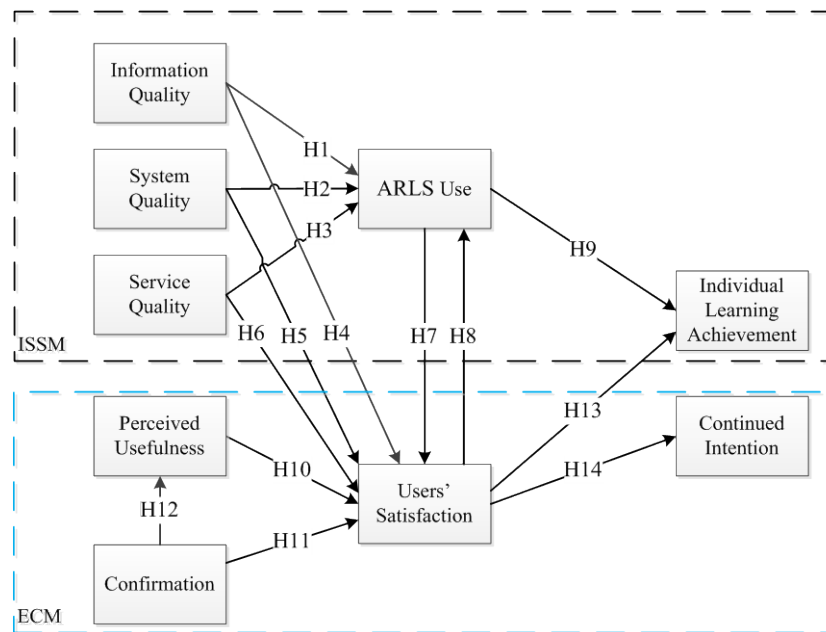


Figure 5 Research Model EISSM.

3. Methodology

3.1 Questionnaire: Instrument development and assessment of validity and reliability

In initial phrase of this study, we conducted pilot test on the 40 students who enrolled online courses about network equipment combination, for example learner can follow CISCO router operations and its modules combination with the courses that provided by our prototype ARLS. For measuring e-learning, the survey instrument is developed by adopting existing validated instruments wherever possible. Measurement items for ARLS use and Individual satisfaction were adopted from Cheung (Cheung, Chang, & Lai, 2000) and McKinney(McKinney, Yoon, & Zahedi, 2002). Measurement items for information quality were adopted from DeLone (W. H. DeLone & McLean, 2003). Questions were anchored on a seven-point Likert scale (1 strongly disagree, 7 strongly agree). To improve content reliability, the list of categorized measures was subsequently screened by an academic in charge of an augmented reality community group. We also judged construct validity by determining convergent and discriminant validity based on the level of consistency within the categorization of items (Moore & Benbasat, 1991).

4. Preliminary Results

Preliminary results in this work as shown in Table 1, the questionnaire was pilot-tested by convenient sampling. There were 40 responses, of which 37 were complete, giving a valid response rate of 92%, and the results of the pilot test were evaluated by using Cronbach's reliability and factor analysis. The reliability coefficient was first calculated for the items of each construct, and the standard lower bound for Cronbach's alpha set at 0.7 (Anderson & Gerbing, 1988), with items that did not significantly contribute to the reliability being eliminated. A factor analysis was then performed to examine whether the items produced the anticipated number of factors and whether the individual items were loaded on their appropriate factors. All items had high loadings on their related factors and low cross-loadings on other factors, which denote good convergent and discriminate validities in the questionnaire.

The next progresses about our work, an completed AR-learning system will be constructed for collecting entire user learning data in unsupervised learning environment; in turn conduct data analysis with PLS (partial least squares, PLS), which is suitable for our study for several reasons. First, PLS can test the psychometric properties of the indices and provide better evidence for the existence of relationships. Secondly, the investigation of this model is exploratory in nature. Thirdly, PLS has less

stringent standards regarding sample size, distribution parameters, and levels of correlation between variables. For this study, PLS-Graph version 3.00 Chin (Chin & Frye, 1996) and the bootstrap resampling method may be used to evaluate the measurement and structural models. We will perform data analysis in accordance with a two-stage methodology, Gerbing (Anderson & Gerbing, 1988) using PLS. The first step in the data analysis will establish the convergent and discriminant validity of constructs using the measurement model. The second step will test the structural model

Table 14 Results of reliability and validity tests.

Item	Factor loading	AVE	CR	Cronbach α
Information quality 1	0.852	0.76	0.891	0.83
Information quality 2	0.831			
Information quality 3	0.912			
System quality 1	0.725	0.683	0.840	0.903
System quality 2	0.728			
System quality 3	0.731			
System quality 4	0.828			
Service quality 1	0.767	0.689	0.913	0.917
Service quality 2	0.814			
Service quality 3	0.873			
Service quality 4	0.842			
Service quality 5	0.836			
Service quality 6	0.847			
ARLS use 1	0.697	0.684	0.954	0.926
ARLS use 2	0.737			
ARLS use 3	0.902			
ARLS use 4	0.913			
User Satisfaction 1	0.891	0.834	0.934	
User Satisfaction 2	0.913			
User Satisfaction 3	0.932			
User Satisfaction 4	0.941			
Learning Achievement 1	0.841	0.804	0.826	0.897
Learning Achievement 2	0.892			
Learning Achievement 3	0.873			
Learning Achievement 4	0.887			
Learning Achievement 5	0.932			
Learning Achievement 6	0.918			
Learning Achievement 7	0.924			
Perceived usefulness 1	0.931	0.867	0.871	0.871
Perceived usefulness 2	0.921			
Perceived usefulness 3	0.945			
Perceived usefulness 4	0.913			
Confirmation 1	0.797	0.783	0.896	0.897
Confirmation 2	0.837			
Confirmation 3	0.812			
Confirmation 4	0.883			
Continue intention 1	0.817	0.846	0.886	0.876
Continue intention 2	0.846			
Continue intention 3	0.855			

5. Conclusion and next progresses

Prior e-learning studies have found learner's learning achievement were inconsistent while they use e-learning through AR technology, and the acceptance-discontinuance anomaly phenomenon is a common occurrence. The questions are very interesting because it implies there are some critical factors positively or even negatively influence on users' learning achievement and acceptance behavior in the context. In order to explore the factors and answer the questions, this study proposed an extension model from ISSM, ECM and integrating the characteristics from user experience.

The preliminary pilot-test results of this study have shown our questionnaire reached good convergent and discriminate validities. We expect our research will present important theoretical and practical contributions. On the theoretical side, this study will develop and test the novel research model. Practically, this study will provide guidelines for practitioners to improve learning achievement in e-learning through AR technologies. Overall, this study is expected contribute toward the theoretical achievement of AR usage and provides insights into improving the e-learning through user experience. In our next steps, a complete AR e-learning system will be established to validate our research model. We expect the system well be a potential learning tool, since there were few empirical studies to measure user experience and utilize it to support e-learning with AR, this study is expected to attract interest in further research on e-learning areas.

Acknowledgement

The authors would like to thank the National Science Council of the Republic of China for financially supporting this research under Contract No. NSC 101-2511-S-432-001- and NSC 102-2511-S-432-001-.

References

- Anderson, J. C., & Gerbing, D. W. (1988). Structural Equation Modeling in Practice: A Review and Recommended Two-Step Approach. *Psychological Bulletin*, 103(3), 411-423.
- Baird, D. E., & Fisher, M. (2005). Neomillennial user experience design strategies: Utilizing social networking media to support "always on" learning styles. *Journal of educational technology systems*, 34(1), 5-32.
- Bearden, W. O., & Teel, J. E. (1983). Selected determinants of consumer satisfaction and complaint reports. *Journal of Marketing Research*, 21-28.
- Bhattacharjee, A. (2001). Understanding information systems continuance: an expectation-confirmation model. *MIS quarterly*, 25(3), 351-370.
- Bhattacharjee, A. (2001). Understanding information systems continuance: An expectation-confirmation model. *MIS Quarterly: Management Information Systems*, 25(3), 351-370.
- Cheung, W., Chang, M. K., & Lai, V. S. (2000). Prediction of Internet and World Wide Web usage at work: A test of an extended Triandis model. *Decision Support Systems*, 30(1), 83-100.
- Chin, W. W., & Frye, T. (1996). *PLS Graph (Version 2.91.03.04)*.
- Davis, F. D. (1985). *A technology acceptance model for empirically testing new end-user information systems: Theory and results*. Massachusetts Institute of Technology, Sloan School of Management.
- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly*, 319-340.
- Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. *Management Science*, 35(8), 982-1003.
- DeLone, W. (2003). The DeLone and McLean Model of Information Systems Success: A Ten Year Update. *Journal of Management Information Systems*, 19(4).
- DeLone, W. H., & McLean, E. R. (1992). Information systems success: The quest for the dependent variable. *Information Systems Research*, 3(1), 60-95.
- DeLone, W. H., & McLean, E. R. (2003). The DeLone and McLean model of information systems success: A ten-year update. *Journal of Management Information Systems*, 19(4), 9-30.
- Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention and behavior: An introduction to theory and research*.
- Gefen, D., & Straub, D. W. (1997). Gender differences in the perception and use of e-mail: An extension to the technology acceptance model. *MIS quarterly*, 389-400.
- Igbaria, M. (1990). End-user computing effectiveness: A structural equation model. *Omega*, 18(6), 637-652.

- Müller, D., Law, E. L. C., & Strohmeier, S. (2010). *Analysis of the Persuasiveness of User Experience Feedback on a Virtual Learning Environment*. Paper presented at the Proceedings of International Workshop on the Interplay between User Experience.
- McKinney, V., Yoon, K., & Zahedi, F. (2002). The measurement of Web-customer satisfaction: An expectation and disconfirmation approach. *Information Systems Research*, 13(3), 296-315.
- Moore, G. C., & Benbasat, I. (1991). Development of an instrument to measure the perceptions of adopting an information technology innovation. *Information Systems Research*, 2(3), 192-222.
- Oliver, R. L. (1993). Cognitive, affective, and attribute bases of the satisfaction response. *Journal of Consumer Research*, 418-430.
- Oliver, R. L., & DeSarbo, W. S. (1988). Response determinants in satisfaction judgments. *Journal of Consumer Research*, 495-507.
- Pitt, L. F., Watson, R. T., & Kavan, C. B. (1995). Service quality: A measure of information systems effectiveness. *MIS Quarterly: Management Information Systems*, 19(2), 173-185.
- Szymanski, D. M., & Henard, D. H. (2001). Customer satisfaction: a meta-analysis of the empirical evidence. *Journal of the academy of marketing science*, 29(1), 16-35.
- Taylor, S., & Todd, P. (1995). Assessing IT usage: The role of prior experience. *MIS quarterly*, 561-570.
- Taylor, S., & Todd, P. A. (1995). Understanding information technology usage: A test of competing models. *Information Systems Research*, 6(2), 144-176.
- Venkatesh, V. (2000). Determinants of perceived ease of use: Integrating control, intrinsic motivation, and emotion into the technology acceptance model. *Information Systems Research*, 11(4), 342-365.
- Yuviler-Gavish, N., Yechiam, E., & Kallai, A. (2011). Learning in multimodal training: Visual guidance can be both appealing and disadvantageous in spatial tasks. *International journal of human-computer studies*, 69(3), 113-122.

Establishing an Innovative Plant Learning Platform with Expandable Learning Materials Using Wiki Software

Shu-Chen Cheng, Chien-Ming Shao

Department of Computer Science and Information Engineering Southern Taiwan

University of Science and Technology, Taiwan

kittyc@mail.stust.edu.tw

Abstract: Currently, plant education in elementary schools is an insignificant part of Nature courses, and students learn only the basic knowledge of plants, rather than profound knowledge. This study aims to establish an innovative plant learning platform to help students gain knowledge of plants, as based on the instructional website of a wiki engine. Through the characteristics of wiki, it invites scholars in plant studies to edit plant data and design related tests on the platform. Students can check their knowledge of plants on this system by various platforms, such as computers or mobile phones. The keywords can be the characteristics of leaves, flowers, and names of plants. In the experiment of study, a pretest is conducted on students using the items proposed by scholars, and a posttest is conducted after the students used the proposed system. The results of the two tests were compared. This study anticipates that the proposed system can allow students to have higher interest in learning about plants, thus gaining more knowledge on plants.

Keywords: Wiki, Plant Search System, U-Learning

1. Introduction

Research Background

At present, elementary school students learn about plants in the Nature courses, and the courses on plants account for a small part of the Nature courses. Some schools erect signage alongside plants for simple introduction. Those methods can only provide students with limited knowledge on plants. Using the plant features search system, a wiki engine, and mobile devices, this study aims to construct an encyclopedia learning system of plants in order to enhance elementary school students' knowledge and interest in plants.

In addition to the search of leaf features, this study includes the flower features as reference for search. By multiple search methods, users can find their searched plants.

Research Purposes

The purpose of this study is to establish an encyclopedia learning system of plants in order to help elementary school students gain knowledge of plants. After the students have used the system, the researcher obtains their feedbacks and determines whether the system is effective. The design of the system is to add a function of wiki in a plant features search system, as the wiki has advantages in data editing and expansion. The experts can contribute their knowledge on the platform, and students can search for plant information on the webpage. The proposed system is expected to enhance students' interest in plants and their knowledge.

2. Literary Reviews

The plant search system quantifies leaf features by fuzzy function

Currently, there are few methods to search for plant information, and the search is particularly difficult for people lacking knowledge of plants. The common search method is one-by-one comparison of Kingdom, Phylum, Class, Order, Family, Genus, and Species of Biological Classification. Only plant experts, who are used to careful observations of plants, are familiar with the comparison, and it is difficult for the public to search for plants by the same method.

Cheng, Jhou, & Liou (2007) proposed the classification of plants by leaf. The leaf of each species of plant is unique, thus can be used as the reference for classification. The leaf features include 8 types, which are apex, base, margin, arrangement, vein, size, and growth. Users can select the feature items, and use fuzzy function for comparison with the plant data in the database. The score of the plant feature is calculated, a higher score indicates the higher probability of the search results.

By this method, users can quickly and precisely find plants. Moreover, considering that mobile devices are popularly used, a mobile version of the proposed system is also developed, allowing users to use this study outdoors.

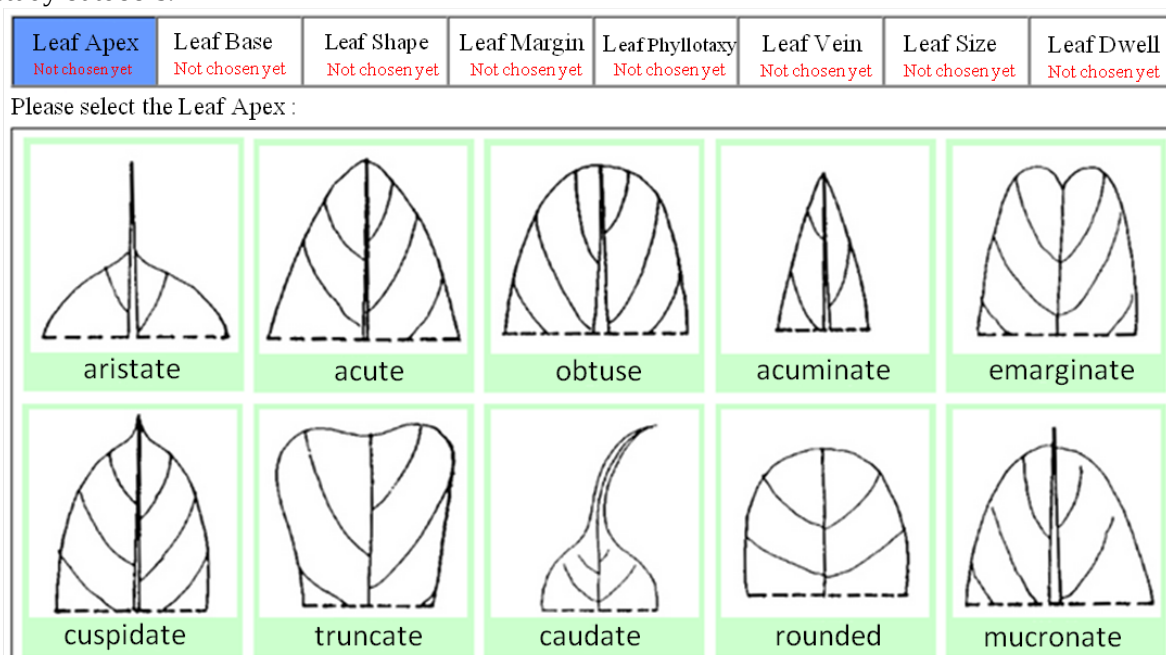


Figure 1. Interface of the feature selection of the leaf apex (Cheng, Jhou, & Liou (2007))

Plant search system on mobile devices

In order to help people learning about the plants they see outdoors, Cheng, Jhou, & Liou (2007) developed a leaf features search system using fuzzy function on the PDA platform, which can be used outdoors. With this system, users can search for and read information anywhere about plants with a PDA.

Although the PDA version is convenient, the number of PDA users is few. Thus, this study modified the system on Android, as it has become popular in recent years. It is expected that the Android platform will attract more users.

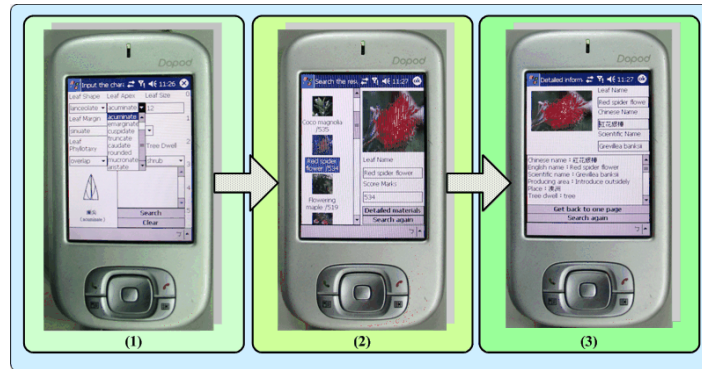


Figure 2. Interface of the mobile plant search system (Cheng, Jhou, & Liou (2007))

Other plant learning application

In order to allow elementary school students to approach plants on campus, Hwang, Chu, Huang, & Huang (2011) suggested combining PDA and RFID technology, and placing sensors on plants around campus, thus allowing students to find plants according to searched items on PDA through RFID. If the result is wrong, the students will be provided with clues to find the correct plants. Test questions on the plants will then be shown, and students can answer the questions after observing the plants. The students are thus encouraged to approach plants and gain plant knowledge.

Huang's experiment was based on RFID and PDA. However, RFID was only installed on plants on campus, thus, the system cannot be used outside of the school. The leaf features search system can solve this problem.



Figure 3. Interface of the ubiquitous learning system(Hwang, Chu, Huang, & Huang (2011))

Wiki engine

Wiki engine is a hypertext system created by the collaboration of many people, where users can freely establish and edit explanation items (Shih, Tseng, & Yang, 2008). The most well-known website that uses wiki engine is Wikipedia. At present, Wikipedia has constructed more than 20 million pieces of data, and public editing can easily expand the data. However, the disadvantage is that most of the information is not proved, or is fabricated by the editors, thus, it is not reliable. In order to establish a website of knowledge by this function, the editors should be professional personnel in order to minimize the error rate and increase the readability of items.

3. Method

Content of the plant knowledge website

This study plans to invite scholars and experts in the field of plant studies to edit the data, thus ensuring the accuracy and readability of the information. The teaching materials compiled using wiki can allow multiple editors to work on the content, making it easier to expand data, as compared to ordinary

textbooks. The advantage is that after one editor finishes writing, other editors can examine the content, and supplement or revise the content at any time.

In addition to contributing the information on plants, the functions of wiki also allow the scholars to construct an item bank on plant knowledge. The numerous contributors also enhance the expandability of the item bank, while specifically targeting at learners of different ages. As a result, the learning effectiveness on plant knowledge will be enhanced.

Plant search system

As an extension of the leaf features search function, the proposed system includes the function of flower features search. The features of flowers include color, form, flowering period, and inflorescence. Using the theory of fuzzy function, this study constructs a search system according to the flower features, allowing the search results to be more precise.

Plant search system on mobile devices

The original version of the plant features search system for mobile devices was designed for PDA. However, the number of PDA users has decreased in recent years. Considering the rise of smart phones, this study uses the Android system to modify the search system, so that it can be used on smart phones and tablet PC. By accessing the Internet through 3G, users can search for information at anytime and anywhere. In comparison to the RFID system on plants at schools, the search range can move beyond the campus, thus achieving ubiquitous learning.

Use of the website by the students

A pretest is conducted using the questions created by the scholars in order to determine students' current plant knowledge. The students can access the website via a computer or a mobile device. After students use the proposed system, a posttest is conducted to evaluate the learning outcomes.

4. System Architecture

Editing system for experts

The plant information is edited by plant experts and scholars using the wiki engine. System flow shown in Figure 4, They first search the plant items in the database for editing, and the data of the plants selected will be shown. They then determine if the content needs to be revised. If plant information cannot be found, they can add the item by creating a new page for such plants. Moreover, they can update the data in the database, and the new data will be displayed for the users.

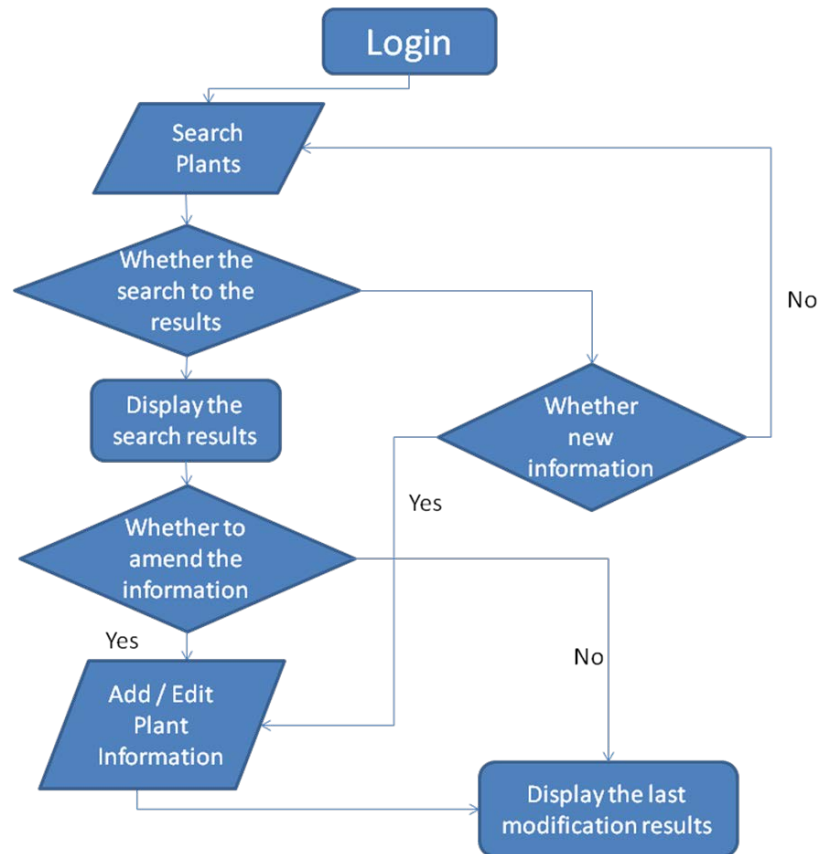


Figure 4. Flow chart of editing system for experts

Search system for students

When students visit the website, search process shown in Figure 5, they can search for plants by keying in the leaf and flower features, which will be transmitted to the system to calculate the plants matched. By fuzzy function, the system calculates the plants matching the inputted features, and displays the plants that match the features by score ranking. It is noted that the plant with the highest score may not be the plant that the users intend to search; this is probably because the users have chosen the wrong features or failed to input features. In this case, the system calculates the search result, according to other correct features. The users can browse the search results to find the plant that they intend to search.

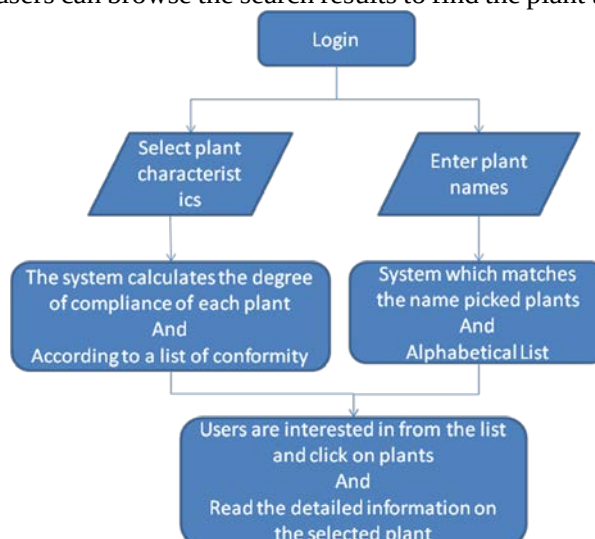


Figure 5. Flow chart of the search system for students

Experimental Procedure

This research will find two classes of elementary school students as experimental subjects, the experimental group and the control one. The control group will be taught using traditional methods of lecturing while the experimental group will experience the plant learning system. The experimental time is expected to last for four weeks. The experimental procedures are as follows:

Step 1: The two groups will do the pretest according to the questions designed by experts.

Step 2: Introduce the plant learning system to the experimental group.

Step 3: The two groups will do the posttest after 4-week experiments.

Step 4: Ask the participants in the experimental group to fill out the system satisfaction questionnaire.

5. Conclusions

Using the wiki engine, this study constructs a learning system that can easily expand plant knowledge, and allow scholars to revise or input plant data. The database of this system has high expandability on plant information, and provides accurate plant knowledge contributed by scholars. Besides the plant data, the wiki engine is also used to construct an item database for the testing system. It is easy to manage, can provide pretest and posttest functions, and allow students to self-test their plant knowledge.

Students can use this system on multiple platforms, such as computer, smart phone, and tablet PC, with access to the Internet. Moreover, they can immediately search for plant information when they see plants outdoors, achieving ubiquitous learning outside of campus.

Based on the above, the proposed system is expected to effectively assist students in learning plant knowledge, and increase their interest in plants to cultivate the next generation of plant experts.

References

- Bennett, S., Bishop, A., Dalgarno, B., Waycott, J., & Kennedy, G. (2011). Implementing Web 2.0 technologies in higher education: A collective case study. *Computers & Education*, 59 (2), 524-534.
- Biasutti, M., & EL-Deghaidy, H. (2012). Using Wiki in teacher education: Impact on knowledge management processes and student satisfaction. *Computers & Education*, 59 (3), 861-872.
- Cheng, S.C., & Huang, T.Y. Constructing A Plant Learning System Based On Web 2.0. *ICCE2009*. Hong Kong Institute of Education. Hong Kong.
- Cheng, S. C., Jhou, J.J., & Liou, B.H. (2007). PDA Plant Search System Based on the Characteristics of Leaves Using Fuzzy Function. *Lecture Notes in Artificial Intelligence*, 4570, 834-844.
- CHENG, S.C., PEN, I.C., & LIN, Y.C. Evaluation for the Test Quality of Dynamic Question Generation by Particle Swarm Optimization for Adaptive Testing. *ICCE2012*. Nanyang Technological University. Singapore.
- Huang, Y.M., Kuo, Y.H., Lin, Y.T., & Cheng, S.C. (2008). Toward Interactive Mobile Synchronous Learning Environment with Context-awareness Service. *Computers & Education*, 51(3),1205-126.
- Huang, Y.M., Lin, Y.T., & Cheng, S.C. (2010). Effectiveness of a mobile plant learning system in a science curriculum in Taiwanese elementary education. *Computers & Education*, 54(1),47-58.
- Hwang, G.H., Chu, H.C., Huang, Y.T., & Huang, S.H. Motivation and Effectiveness Analysis of Formative Evaluation Strategies in Ubiquitous Learning Environment. *TWELF2011*. Taipei. Taiwan.
- Moskaliuk, J., Kimmerle, J., & Cress, U. (2011). Collaborative knowledge building with wikis: The impact of redundancy and polarity. *Computers & Education*, 58(4), 1049-1057.
- Shih, W.C., Tseng, S.S., & Yang, C.T. (2008). Wiki-based rapid prototyping for teaching-material design in e-Learning grids. *Computers & Education*, 51(3), 1037-1057.

Development and Evaluation of a Problem Solving Oriented Game-Based Learning System

Hsin-Yi LIANG^a, Song-Yu MEI^a, Yu-Syuan WANG^b, Jhih-Liang JIANG^b,
Gwo-Haur HWANG^{c*} & Chen-Yu LEE^c

^a Graduate Institute of Network Learning Technology, National Central University, Taiwan

^b Department of Information Technology, Ling Tung University, Taiwan

^c Department of Information Networking and System Administration, Ling Tung University, Taiwan

*ghhwang@mail.ltu.edu.tw

Abstract: Problem solving is an intellectual skill to achieve effective learning, and it can be widely applied to many domains. In order to improve the problem solving abilities, previous studies had shown the significant effects of game-based learning to promote students' learning. Besides, previous researches also suggested the cognitive style plays an essential role to affect the usability of game-based learning, which significantly influences the learning effectiveness. Therefore, the differences of cognitive styles on usability evaluation are considered in this study. Two quests are designed in our game-based learning system to improve students' problem solving abilities. The first quest is helpful to promote the mathematical logic and reasoning abilities, while the second quest is helpful to promote the verbal logical reasoning ability. 49 students from two universities in Taiwan participate in this experiment. According to the analysis of cognitive style questionnaires, there are 9 serialist participants and 28 holist participants for the valid samples. In order to improve the system design, the Nielsen's heuristic evaluation questionnaires are applied. The major result indicates that the Nielsen's eighth heuristic (aesthetic and minimalist design) is most satisfied by the participants, while the Nielsen's sixth heuristic (recognition rather than recall) is most dissatisfied. Even some differences are observed, there are no significant differences of the usability evaluation between serialist participants and holist participants.

Keywords: System development, system evaluation, problem solving, game-based learning

1. Introduction

Problem solving is an intellectual skill to achieve effective learning (Liu, Cheng, & Huang, 2011). Previous research modeled there are four stages of problem solving, that is, to identify and understand the problem, to organize the proper strategies, to carry out the plan, and to look back the problem solving process (Polya, 2008). For the reason, problem solving requires multiple abilities, such as analysis of related information, organization, creative thinking, and critical evaluations (Publishing, 2009). Besides, problem solving abilities can be widely applied to many domains, for example, computer sciences, mathematics, social sciences, and design (Hwang, Wu, & Chen, 2012). Previous research also indicated problem solving abilities are positively related to the learning performance and high-level thinking abilities (Hwang et al., 2012). Hence, there address the need to improve students' problem solving abilities.

To improve the problem solving abilities, there is a need to provide students enough opportunities and practices through related problem solving activities (Polya, 2008). However, many studies argued the effectiveness of traditional learning (Lee & Chen, 2009). More specifically, in a traditional learning context, students learn to passively copy the standard solution methods step by step. Therefore, students easily forget the procedures due to lack of self-awareness and feedback (Polya, 2008). Moreover, the insufficient thinking and reasoning process also limited the improvement of problem solving abilities (Lee & Chen, 2009). As a result, students have difficulties to apply proper strategies in solving problems in novel situations.

For the reason, there is a need to encourage students actively reflect on learning and provide sufficient feedback to support learning. On the other hand, previous studies have shown the significant

effects of game-based learning to promote students' learning (Gee, 2003; Pahl & Rowsell, 2012). The interactive environment not only improves the playfulness of learning, but also gives students immediate feedback to reflect on their learning (Tao, Yeh, & Hung, 2012). Moreover, game-based learning provides students a flexible learning environment, which promotes students developing various strategies to solve problems (Elia, van den Heuvel-Panhuizen, & Kolovou, 2009). In other words, game-based learning can significantly improve students' performance of problem solving through non-routine problem solving activities (Lee & Chen, 2009). Therefore, this study developed a game-based learning system to promote students' problem solving abilities.

Despite of such advantages of game-based learning to improve the problem solving abilities, there are some design issues which affect the learning effectiveness, such as disoriented problems (Webster & Ahuja, 2006), difficulties of manipulation (Kiili, 2005), and influences of multimedia (Hastings & Tracey, 2004). Besides, previous research also suggested cognitive style significantly affects student's preferences and behaviors, which plays an essential role to affect learning effectiveness in game-based learning (Ford, 1985; Frias-Martinez, Chen, Macredie, & Liu, 2007). Therefore, there is a need to take cognitive style into consideration to improve the learning effectiveness.

Regarding the system design, previous studies have shown usability is a strong predictor of such design issues (Schell, 2008). Indeed, the usability highly affects students' performance and perceptions (Virvou & Katsionis, 2008). In this vein, usability is evaluated in this study to improve the design of system. Nielsen's heuristic approach is selected because it is the most commonly used and can be effectively applied by both novices and experts (Nielsen, 1994; Nielsen & Mack, 1994). Moreover, Nielsen's heuristic approach evaluates the system from various aspects, for instance, the interface design, help and instruction, and the feedback of interactions. Therefore, Nielsen's heuristic approach is more effective to identify the design problems comparing to the other methods of usability evaluations, such as user testing and cognitive walkthrough (Fu, Salvendy, & Turley, 2002).

In brief, a game-based learning system is developed in this study to improve students' problem solving abilities. Nielsen's heuristic evaluation of usability is used to improve the design of this system. Besides, the differences of cognitive styles on usability evaluation are also discussed to satisfy individual needs. The methodology and result will be discussed in the following sections. Besides, the design guideline will be posed for the future studies and the improvement of this system.

2. Development of System

2.1 System Architecture

Adobe Flash is selected to develop our proposed game-based learning system. This is due to the fact that Adobe Flash has been widely used in the development of game-based learning programs, e.g., mathematics education (Shafie & Ahmad, 2010), college education (Kuk, Milentijević, Rančić, & Spalević, 2012), and energy efficient education (Cowley, Moutinho, Bateman, & Oliveira, 2011). Additionally, it includes many attractive features, such as the ease of learning. Furthermore, it provides with strong graphic capabilities, which are not available in other standard programming languages (Lee & Lee, 2007). In order to improve students' problem solving abilities, there are two quests in our game-based learning system. The first one is a mathematical logic and reasoning quest, and the second one is a verbal logical reasoning quest. The details of two quests are described below.

2.2 The First Quest

In the first quest, as shown in Figure 1(a), the road towards to a town is blocked by a landslide because of the heavy rain. Therefore, players are required to clear the blocks to enter the town. A dog guard is able to help players finding out the instructions from the landslide to operate the machine to clear the blocks. According to the instructions, players can infer the answer and improve the mathematical logic and reasoning abilities. After the start of the quest, there are a timer and a give up button on the top screen, and a goal button and a hint button are on the bottom left screen. The setting is illustrated as shown in Figure 1(b). If players click the instructions directly without the help of the dog guard, it will

result in a collapse and game over as shown in Figure 1(c). When players click the give up button, a dialog box including continue button and quit button will be appeared as shown in Figure 1(d). If players click the goal button, the goal of the quest will be popped up as shown in Figure 1(e). If players click the hint button, the instruction to pass the quest will be popped up as shown in Figure 1(f). By the help of the dog guard, the instructions including the logical reasoning rules will be obtained and appeared on the top of the panel of machine as shown in Figure 1(g). When passing the quest, it will pop up players' information such as gained experiences, gained game coins, gained logical reasoning abilities, time to spend, and times to click hints in a congratulation dialog box as shown in Figure 1(h).



(a)



(b)



(c)



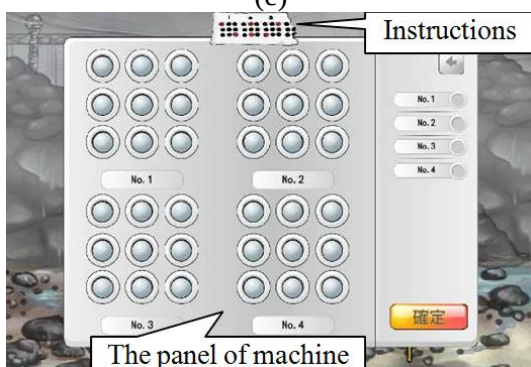
(d)



(e)



(f)



(g)



(h)

Figure 1. The interface in the first quest.

2.3 The Second Quest

There are two related topics in the second quest. At first topic, players have to find out the characters of the highest grade. The goal of second topic is to find out the character that destroyed the piggy's toy car. For these two topics, some questions are needed to be solved by the players. If players give wrong answers for three times, then they will fail to conquer this quest, and the game is over. Because of similarity of these two topics, only related figures of the first topic are illustrated as follows.

The piggy is crying because his toy car is broken, players have to find out the destroyer as shown in Figure 2(a). A lot of buttons are provided with caption boxes as shown in Figure 2(b). The hearts represent a player's life, and it means the number of times left to answer the question. If players want to give up the quest, the give up button is available. If the item buttons and NPC buttons are pressed, some verbal clues will be appeared. The functions of the goal button and the hint button are similar to those in the first quest, and the illustrations are shown in Figure 2(c) and Figure 2(d), respectively. After reading the clues, players can click the start answer button to start answering questions as shown in Figure 2(e). While all questions being answered correctly, the explanation of the answers will be clarified to promote the verbal logical reasoning ability as shown in Figure 2(f).



Figure 2. The interface in the second quest.

3. Methodology

The process of the experiment is listed as shown in Figure 3. At first, all participants have to fill out cognitive style questionnaires developed by Ford (1985), and then the whole process is explained. Afterwards, the participants login the assigned website to play the game. After passing all quests, the participants have to fill out Nielsen's Heuristic Evaluation questionnaires.

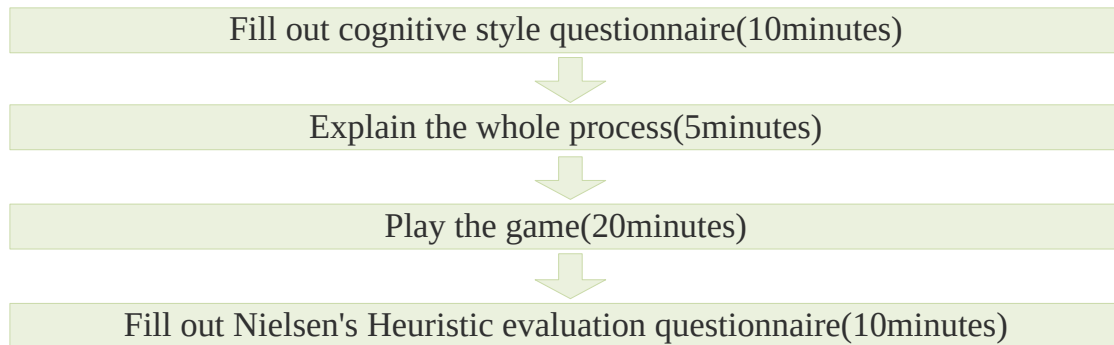


Figure 3. The experiment process.

The participants of the experiment are 49 students from two universities in Taiwan, and their major is information technology. There are 37 valid samples and 12 invalid ones. In this study, the statistical software of SPSS 19 is used to analyze the valid samples, and the overall reliability is .914. According to the analysis of cognitive style questionnaires, there are 9 serialist participants and 28 holist participants for the valid samples as shown in Table 1.

Table 1: The cognitive style of participants.

	Serialist	Holist	Total
Valid samples	9	28	37
Invalid samples	3	9	12
Total	12	37	49

4. Result and Discussion

The descriptive statistics of valid samples as well as their rank of Nielsen's ten heuristics is listed in Table 2. According to the analysis, the top rank of the heuristic is H8 (aesthetic and minimalist design) with the average score of 3.74. It means the visual design of this game is most satisfied by the players. On the other hand, the least satisfied heuristic is H6 (Recognition rather than recall) with the average score of 2.91. In other words, most players consider insufficient available information to be provided in this system.

Table 2: Descriptive statistics of valid samples and their rank of Nielsen's ten heuristics.

Nielsen's ten heuristics	N	Mean	S.D.	Rank
H1:Visibility of system status	37	3.21	.71	9
H2:Match between system and the real world	37	3.26	.78	6
H3:User control and freedom	37	3.32	.69	5
H4:Consistency and standards	37	3.23	.74	7
H5>Error prevention	37	3.35	.61	3
H6:Recognition rather than recall	37	2.91	.73	10
H7:Flexibility and efficiency of use	37	3.41	.76	2

H8:Aesthetic and minimalist design	37	3.74	.60	1
H9:Help users recognise, diagnose and recover from errors	37	3.23	.79	8
H10:Help and documentation	37	3.35	.83	4

Furthermore, the influence of the cognitive style is also considered as shown in Table 3. The top three ranks of heuristics satisfaction for the serialist group are H8, H10 (help and documentation), and H1 (visibility of system status), and the bottom three ones are H6, H9 (help users recognise, diagnose and recover from errors), and H5 (error prevention). On the other hand, the top three ranks of heuristics satisfaction for the holist group are H8, H7 (flexibility and efficiency of use), and H5, and the bottom three ones are H6, H1, and H4 (consistency and standards). For both groups of serialist and holist, the top rank of heuristics satisfaction is H8 (aesthetic and minimalist design), and the bottom rank of heuristics satisfaction is H6 (recognition rather than recall).

However, it observed some noticeable differences of satisfaction for H1 and H5 between serialist group and holist group. The heuristic H1 is at the third rank for the serialist group, but it is at the ninth rank for the holist group. In other words, the visibility of system status (H1) is much satisfied by the serialist group, but the contrary result is provided by the holist group. The heuristic H5 is at the eighth rank for the serialist group, but it is at the third rank for the holist group. That means error prevention (H5) is much satisfied by the holist group, but the contrary result is provided by the serialist group.

Table 3: Descriptive statistics and the ranks of Nielsen's ten heuristics for the serialist group and the holist group.

Nielsen's ten heuristics	Serialist				Holist			
	N	Mean	S.D.	Rank	N	Mean	S.D.	Rank
H1	9	3.33	.67	3	28	3.17	.73	9
H2	9	3.22	.55	7	28	3.27	.85	6
H3	9	3.26	.46	5	28	3.33	.75	4
H4	9	3.26	.55	6	28	3.23	.80	8
H5	9	3.22	.52	8	28	3.39	.64	3
H6	9	2.92	.52	10	28	2.90	.80	10
H7	9	3.33	.60	4	28	3.44	.81	2
H8	9	3.63	.59	1	28	3.77	.61	1
H9	9	3.15	.71	9	28	3.26	.83	7
H10	9	3.41	.86	2	28	3.33	.84	5

Thus, in order to verify the differences of the usability evaluation between two groups, *t* test is used to analyze. The result indicates there are no significant differences between the serialist group and the holist group for Nielsen's ten heuristics as shown is Table 4.

Table 4: *t* test for the differences of heuristics satisfaction between the serialist group and the holist group.

Nielsen's ten heuristics	Cognitive style	N	Mean	S.D.	<i>t</i>
H1:Visibility of system status	serialist	9	3.33	.67	.547
	holist	28	3.17	.73	
H2:Match between system and the real world	serialist	9	3.22	.55	.865
	holist	28	3.27	.85	
H3:User control and freedom	serialist	9	3.26	.46	.784
	holist	28	3.33	.75	
H4:Consistency and standards	serialist	9	3.26	.55	.909

	holist	28	3.23	.80	
H5:Error prevention	serialist	9	3.22	.53	.472
	holist	28	3.39	.64	
H6:Recognition rather than recall	serialist	9	2.93	.52	.941
	holist	28	2.90	.80	
H7:Flexibility and efficiency of use	serialist	9	3.33	.60	.718
	holist	28	3.44	.81	
H8:Aesthetic and minimalist design	serialist	9	3.63	.59	.537
	holist	28	3.77	.60	
H9:Help users recognise, diagnose and recover from errors	serialist	9	3.15	.71	.714
	holist	28	3.26	.83	
H10:Help and documentation	serialist	9	3.41	.86	.820
	holist	28	3.33	.84	

Besides, in order to obtain the advanced realization of participants' perceptions and suggestions toward this system, an interview with individual participants is held after the experiment. After organization, it generates 8 codes by the synthesis of interviewers' perceptions and suggestions toward this system as shown in Table 5. These codes are used to complement the inadequate part of the quantitative analysis.

Table 5: The coded interview results.

Code	Code description
A1	Invisibility of the button
A2	Difficulty to realize the hint
A3	Less information to play the game
A4	Consistency of quest button design
A5	Slow Internet connection
A6	Expectation of more contents in the game
A7	Addition of sound effects and background music
A8	Provision of a logout button

The coded interview results mapping to Nielsen's heuristics for the serialist group and the holist group in the first quest is listed and denoted by the format of code(a list of participants' username) as shown in Table 6. Most of participants in the seialist group mention that they cannot understand how to do in the first quest (A3 mapping to H10). They need more information to play the game. One participant in the seialist group mentions that the hint is helpless due to the difficulty to realize (A2 mapping to H9). In the other hand, 8 participants in the holist group mention to the difficulty to realize the hint (A2 mapping to H9). Four participants in the holist group mention to less information to be provided (A3 mapping to H10). One participant mentions to the invisibility of the button (A1 mapping to H1), and another one participant mentions to the consistency of quest button design (A4 mapping to H4).

Table 6: The code for the serialist group and the holist group in the first quest.

Nielsen's heuristics	Serialist	Holist
H1	-	A1(test08)
H4	-	A4(test11)
H9	A2(test09)	A2(test06, test11, test20, test22, test31, test41, test42, test57)
H10	A3(test01, test09, test12, test26, test44)	A3(test05, test10, test41, test47)

The coded interview results mapping to Nielsen's heuristics for the serialist group and the holist group in the second quest is listed as shown in Table 7. Most of participants in the serialist group mention to less information to be provided (A3 mapping to H10). In the other hand, 5 participants in the holist group mention to the difficulty to realize the hint (A2 mapping to H9). Four participants in the holist group mention to the invisibility of the button (A1 mapping to H1), and another two participants think they mention to less information to be provided (A3 mapping to H10).

Table 7: The code for the serialist group and the holist group in the second quest.

Nielsen's heuristics	Serialist	Holist
H1	-	A1(test08, test20, test41, test42)
H9	-	A2(test11, test14, test22, test31, test41)
H10	A3(test01, test09, test12, Test26, test44)	A3(test42, test47)

The coded interview results without mapping to Nielsen's heuristics for the serialist group and the holist group is listed and taken as the suggestions to improve the system design as shown in Table 8. Three participants in the serialist group expect more contents are provided in the game (A6), and one participant in the serialist group expects to add sound effects and background music (A7). In the other hand, 4 participants in the holist group mention to slow Internet connection (A5). Moreover, one participant in the holist group expects to add sound effects and background music (A7), and another one participant in the holist group expects that a logout button is provided (A8).

Table 8: The suggestions proposed by serialist and holist participants to improve the system design.

Serialist	Holist
A6(test04, test10, test14) A7(test38)	A5(test05, test06, test07, test08), A7(test16), A8(test14)

5. Conclusion

A game-based learning system is developed in this study to promote students' problem solving abilities. The usability of Nielsen's heuristic evaluation is used to examine the design of this system. In addition, students' cognitive styles are also considered to measure their influences on the usability evaluation. The major result indicates that the heuristic of aesthetic and minimalist design (H8) is most satisfied while the heuristic of recognition rather than recall (H6) is most dissatisfied. Furthermore, when the influence of the cognitive style is also considered, even some differences are observed, the result shows that there are no significant differences of the usability evaluation between the serialist group and the holist group. Regarding to the result, It is necessary to provide available information as more as possible to improve the system design.

According to the observations of the coded interview results mapping to Nielsen's heuristics, the heuristics of H9 (help users recognize, diagnose and recover from errors) and H10 (help and documentation) are referred to by most participants. Moreover, system performance and attractive playfulness, such as the respond time of Internet connection and audio effects, are also mentioned by some participants.

The results are helpful to improve the proposed game-based learning system in this study. However, some limitations and future studies are listed below. Small sample size is a possible reason to lead to no significant differences of the usability evaluation between the serialists and the holists, thus, a larger sample size is expected in the future studies. Moreover, possible influences of prior students' experiences to play games and the analysis of the students' usage profile are not considered in this study, it is expected to be included in the future studies.

Acknowledgements

This study is sponsored by the National Science Council in Taiwan under the contracts no. NSC 101-2511-S-008-010-MY3 and NSC 102-2511-S-275-003.

References

- Cowley, B., Moutinho, J. L., Bateman, C., & Oliveira, A. (2011). Learning principles and interaction design for 'green my place': a massively multiplayer serious game. *Entertainment Computing*, 2(2), 103-113.
- Elia, I., van den Heuvel-Panhuizen, M., & Kolovou, A. (2009). Exploring strategy use and strategy flexibility in non-routine problem solving by primary school high achievers in mathematics. *ZDM*, 41(5), 605-618.
- Ford, N. (1985). Learning styles and strategies of postgraduate students. *British Journal of Educational Technology*, 16(1), 65-77.
- Frias-Martinez, E., Chen, S. Y., Macredie, R. D., & Liu, X. (2007). The role of human factors in stereotyping behavior and perception of digital library users: a robust clustering approach. *User Modeling and User-Adapted Interaction*, 17(3), 305-337.
- Fu, L., Salvendy, G., & Turley, L. (2002). Effectiveness of user testing and heuristic evaluation as a function of performance classification. *Behaviour & Information Technology*, 21(2), 137-143.
- Gee, J. P. (2003). What video games have to teach us about learning and literacy. *Computers in Entertainment (CIE)*, 1(1), 20-20.
- Hastings, N. B., & Tracey, M. W. (2004). Does media affect learning: Where are we now? *TechTrends*, 49(2), 28-30.
- Hwang, G., Wu, P., & Chen, C. (2012). An online game approach for improving students' learning performance in web-based problem-solving activities. *Computers & Education*, 59(4), 1246-1256.
- Kiili, K. (2005). Digital game-based learning: Towards an experiential gaming model. *Internet and Higher Education*, 8, 13-24.
- Kuk, K., Milentijević, I., Rančić, D., & Spalević, P. (2012). Pedagogical agent in Multimedia Interactive Modules for Learning-MIMLE. *Expert Systems with Applications*, 39(9), 8051-8058.
- Lee, C., & Chen, M. (2009). A computer game as a context for non-routine mathematical problem solving: The effects of type of question prompt and level of prior knowledge. *Computers & Education*, 52(3), 530-542.
- Lee, K. C., & Lee, J. (2007). Programming physics softwares in Flash. *Computer Physics Communications*, 177(1), 195-198.
- Liu, C., Cheng, Y., & Huang, C. (2011). The effect of simulation games on the learning of computational problem solving. *Computers & Education*, 57(3), 1907-1918.
- Nielsen, J. (1994). Usability inspection methods. *Conference Companion on Human Factors in Computing Systems*, 413-414.
- Nielsen, J., & Mack, R. L. (Eds.). (1994). *Usability inspection methods*. New York, NY: John Wiley & Sons.
- Pahl, K., & Rowsell, J. (2012). *Literacy and education*. London, England: Sage Publications.
- Polya, G. (2008). *How to solve it: A new aspect of mathematical method*. Princeton, NJ: Princeton University Press.
- Publishing, F. (2009). In Mackall J. (Eds.), *Problem solving (3rd edition)*. New York, NY: Infobase Publishing.
- Schell, J. (2008). *The art of game design: A book of lenses*. Burlington, MA: Morgan Kaufmann Publishers.
- Shafie, A., & Ahmad, W. F. W. (2010). Design and heuristic evaluation of MathQuest: A role-playing game for numbers. *Procedia-Social and Behavioral Sciences*, 8, 620-625.
- Tao, Y., Yeh, C. R., & Hung, K. C. (2012). Effects of the heterogeneity of game complexity and user population in learning performance of business simulation games. *Computers & Education*, 59(4), 1350-1360.
- Virvou, M., & Katsionis, G. (2008). On the usability and likeability of virtual reality games for education: The case of VR-ENGAGE. *Computers & Education*, 50(1), 154-178.
- Webster, J., & Ahuja, J. S. (2006). Enhancing the design of web navigation systems: The influence of user disorientation on engagement and performance. *MIS Quarterly*, 30(3), 661-678.

Planning and Design of Personalized Dynamic Assessment for Linux Learning

Hsin-Chih LIN* and Cheng-Hong LI

Department of Information and Learning Technology, National University of Tainan, Taiwan

*hclin@mail.nutn.edu.tw

Abstract: This study aims at the development of a personalized dynamic assessment system for Linux learning. The proposed system is divided into three major components, including learning materials, learning resources, and dynamic assessment. After assessing learners' learning states and performance, the proposed system can instruct learners to use appropriate learning materials and resources as feedbacks to complete the given tasks, so that learners can use correct Linux commands with the right syntax. These feedbacks can improve learners' operability on Linux, and can enhance learners' motivation and interests. To well develop the proposed system, the three major components will be reviewed by experts through heuristic evaluation and by users through System Usability Scale (SUS). This paper is to describe the issues of planning and design of our personalized dynamic assessment system. The processes of expert and user evaluation for the proposed system are also discussed.

Keywords: Dynamic assessment, Linux, learning materials, system usability scale (SUS)

1. Research Motive and Purpose

Assessment plays an important role in teaching/learning activities. If teachers can properly perform assessment in their teaching activities, learners' learning performance will be significantly improved. Traditionally, the teaching of Linux takes place in class or at a computer room. Most of teachers type text-based commands one by one on the terminal with a command-line interface, while giving some introduction to the commands. After that, learners practice these commands on their terminals. For those learners used to operate computers on graphical user interfaces (GUI), such as Windows or Mac OS, the function and syntax of a text-based command of Linux may be difficult to understand. As a result, the learners usually use Linux commands through rote memorization. They don't know how to use the command correctly and may not realize the system architecture and the operation process of Linux. Eventually, the learners may lose their interests and confidences on learning Linux.

Dynamic assessment is a technique of using interactive assessment to understand the learners' learning needs and outcomes. Dynamic assessment can also give learners some feedbacks and then encourage learners to perform the given tasks. Unlike traditional Linux teaching, this study aims at the development of a personalized dynamic assessment system for Linux learning. The main concept of the proposed system is to provide dynamic assessment when learners operate the system to learn Linux. After assessing learners' learning states and performance, the system can provide personalized feedbacks, namely learning materials and resources, to enhance learners' operability on Linux, and thereby to help learners to achieve effective learning performance.

In this study, the proposed system is divided into three major components, including learning materials, learning resources, and dynamic assessment. The learning materials further consist of six learning modules that are designed according to traditional materials for teaching Linux. The learning resources are technical documents on the Internet. These documents are classified and aligned according to the six learning modules; learners can read the documents to know how to operate Linux. Dynamic assessment can assess learners' learning states and performance and provide appropriate learning materials and learning resources as feedbacks to learners.

2. Literature Review

2.1 Dynamic Assessment

Dynamic assessment is “graduated prompting assessment” and was proposed by Campioe and Brown (1987). It is based on the idea of Zone of Proximal Development (ZPD) (Vygotsky, 1978). ZPD refers to the situation when learners accept the help of others such as teachers or classmates, they can perform beyond their current level. The dynamic assessment is a technique of interactive assessment that use standardized instructional support as an intermediary. When learners have problems in learning, dynamic assessment can provide appropriate assistance to improve learners’ achievement by tracking the learning process.

Dynamic assessment is also called as formative assessment, assessment for learning, or ongoing assessment (Derrich & Ecclestone, 2006; Stiggins, 2002). According to Black and Wiliam (1998), formative assessment has four main concepts, including sharing learning goals, questioning, self/peer assessment, and feedback. Formative assessment is a systematic process used to share learning goal and to understand the learners' learning progress. Formative assessment can continue to collect evidence during the learning process; the evidence can be used to identify learners' current level of learning and to guide learners to achieve the learning goal. Furthermore, Black and Wiliam (2009) proposed that formative assessment includes five key strategies as follows:

- engineering effective classroom discussion, questions, and learning tasks that elicit evidence of learning;
- providing feedback that moves learners forward;
- clarifying and sharing learning intentions and criteria for success;
- activating students as owners of their own learning;
- activating students as instructional resources for one another.

2.2 Heuristic Evaluation

Heuristic evaluation is an informal usability analysis proposed by Nielsen (1994). This analysis requires three or more experts to evaluate a system or an interface through their self-expertise. When the analysis is completed, these experts can discuss with others and provide solutions. The advantage of this analysis is low cost and short time. Heuristic evaluation is to identify the usability problems in a system or on an interface according to ten indices, including visibility of system status, match between system and the real world, user control and freedom, consistency and standards, error prevention, recognition rather than recall, flexibility and efficiency of use, aesthetic and minimalist design, help users recognize, diagnose, and recover form errors, and finally, help and documentation.

2.3 System Usability Scale

System Usability Scale (SUS) was initially proposed by Brooke (1996) when he was at Digital Equipment Corporation. SUS is a commonly used and freely distributed questionnaire that consists of ten indices; it uses a five-point scale with anchors from “Strongly Agree” and “Strongly Disagree.” The ten indices are developed according to the three usability criteria defined in the ISO 9241-11, including effectiveness: the ability of users to complete tasks using the system and successfully achieve their objectives;

efficiency: how much resource is expended in achieving those objectives;

satisfaction: the users’ immediate reactions using the system.

SUS is an effective and reliable tool for measuring the usability of systems and services, such as hardware, software, mobile devices, websites, and applications.

3. System Planning and Design

The proposed system is divided into three major components, including learning materials, learning resources, and dynamic assessment. The learning materials and learning resources are designed by professional Linux teachers; and the conceptual model of the proposed system is shown as Fig. 1. The learning materials also consist of six Linux learning modules, including User Account/Group Management, System Management, File System, Firewall, Apache, and FTP. The six modules are designed according to traditional Linux teaching materials, which refer to the chapters of “Basic learning about Linux OS” (Tsai, 2010) and “Server learning about Linux OS” (Tsai, 2011) and other related topics such as Linux Disk and File System Management, Account Manager and ACL, Crontab, RPM and SRPN, Internet, Firewall and NAT Server, Apache Server, FTP Server, and so on. The above topics are suitable for beginners. The six modules deal with the overall processes of implementing Apache and FTP server. The learning resources are technical documents on the Internet. These technical documents are written by many online users according to their experience of operating Linux; in this study, the documents are classified and aligned according to the six learning modules so that learners can read the documents for the usage of Linux commands. When learners finish each of the six learning modules, dynamic assessment can assess learners’ learning states and performance and then provide appropriate learning materials and learning resources as feedbacks to learners. These feedbacks can guide learners to complete the implementation of Apache and FTP server.

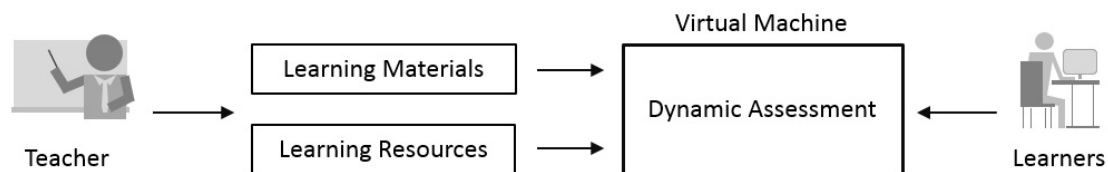


Figure 1. Conceptual model.

The proposed system is packaged with Linux OS in a virtual disk image. After installing a virtual machine on a computer and restore the virtual disk image, learners can practice learning materials and learning resources in an actual Linux environment after class, at any time and any place. In the meanwhile, learners can practice how to plan and manage their virtual Linux environment. In this study, the version of Linux OS is CentOS. When the virtual disk image is restored, CentOS will start up in the virtual machine, as shown in Fig. 2. Afterward, learners can practice the six learning modules through operating CentOS. When learners finish each of the six learning modules, the proposed system can provide the assessment results of the completed module, as shown in Fig. 3. The proposed system provides the appropriate learning materials and learning resources as feedbacks. According to the feedbacks, learners can continue to practice the six learning modules until all practices are correct. When learners finish each of the six learning modules, they can use the function of virtual machine snapshot to quickly restore their Linux environment and then practice again, as shown in Fig. 4. Therefore, learners’ operability in Linux OS will be improved.

In summary, advantages of the proposed system are as follows.

Dynamic assessment is used to assess the learner’s state and performance according to the text-based commands used by learners. When learners operate the proposed system, the system will provide appropriate learning materials and learning resource as feedbacks to learners and to guide them to realize the correct process and steps of implementing Apache and FTP server.

The feedbacks provided by the proposed system can be used to understand the learners’ learning need and outcomes and help learners to achieve effective learning performance on Linux.

When learners finish each of the six learning modules in the virtual machine, they can use the function of virtual machine snapshot to quickly restore their Linux environment and then practice again.

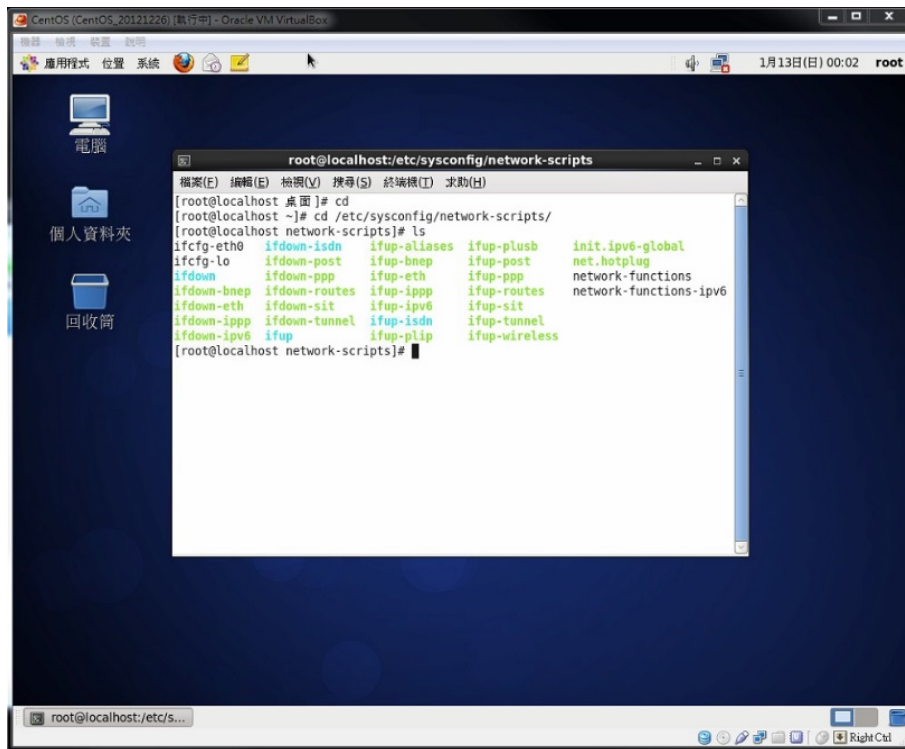


Figure 2. CentOS in the virtual machine.

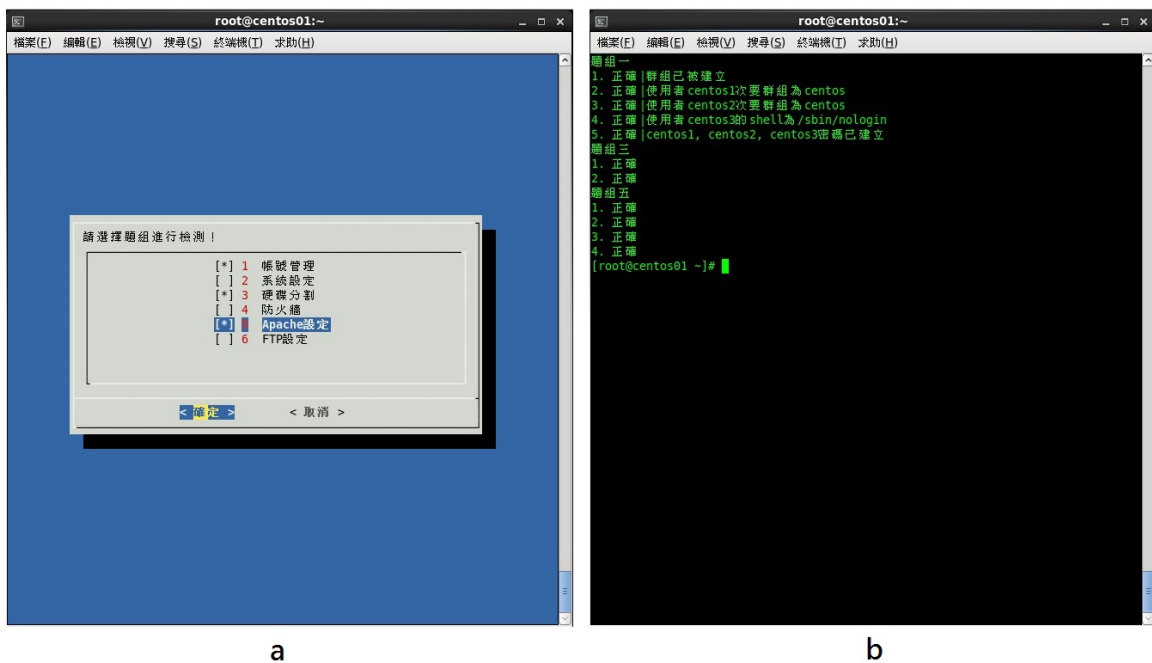


Figure 3. Screenshots of the proposed system. (a) The learner selects the completed module for assessment. (b) The system provides the assessment results.

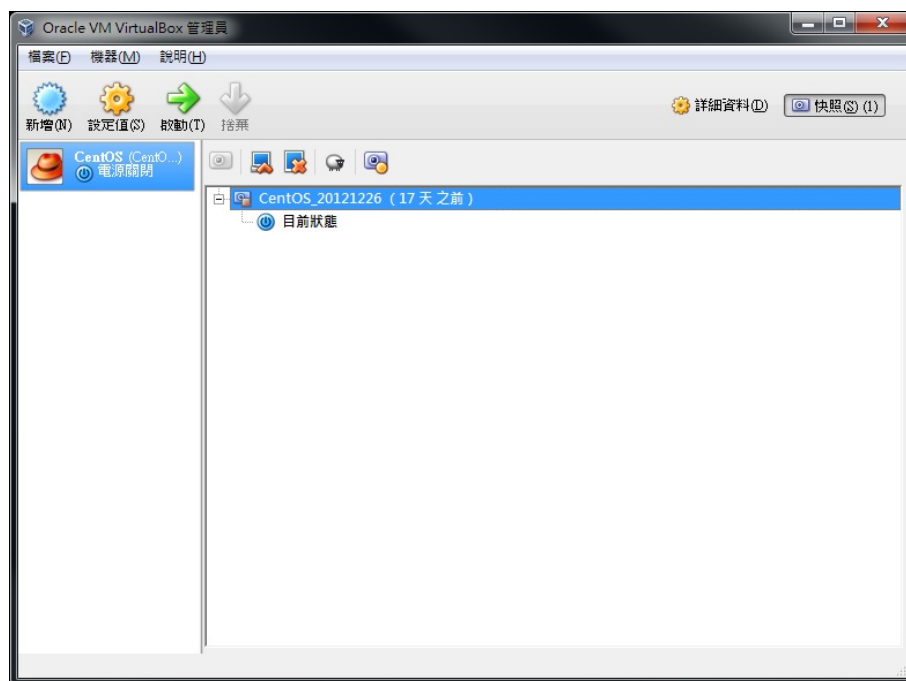


Figure 4. A virtual machine snapshot

Learners can practice the six learning modules through an actual Linux environment after class, at any time and any place; their learning process will be recorded in a system log. After the analysis of the system log, the personalized assessment results will be provided to learners.

In this way, learners can find out their operational or conceptual mistakes through the personalized assessment results and try to compensate for the Linux problem-solving capability they lack; their operability in Linux OS can be also improved.

4. Expert and User Evaluation

4.1 Heuristic Evaluation

The proposed system will be reviewed by experts through heuristic evaluation (Nielsen, 1994). The experts will be asked to follow the ten indices one by one to evaluate the system and to identify the usability problems of the system. The process of heuristic evaluation is as follows:

Domain experts are invited to join the evaluation.

The authors introduce the system and its interface so that experts can well operate the system.

Based on the ten indices, each expert reviews the system individually by her/his expertise.

For each index, the expert must identify the usability problem of the system and write down the reason or a solution, if necessary.

When the evaluation is completed, the experts discuss with others and provide the solution to improve the proposed system.

4.2 System Usability Scale

The proposed system will be also reviewed by users through the use of System Usability Scale (SUS). SUS has ten indices to measure users' subjective evaluation of the system usability. As mentioned before, the measurement results are three-fold, including effectiveness, efficiency, and satisfaction of the system. The use of SUS is as follows:

Users are invited to join the evaluation. The users are graduate and undergraduate students of Computer Science.

The authors introduce the system and its interface so that the users can well operate the system.

Based on the ten indices, each user reviews the system individually by her/his experience.

After reviewing the system, the user starts filling the questionnaire by her/his subjective perception. The questionnaires are analyzed through various statistical methods; the analysis results will be reported and used to improve the system.

5. Conclusions and Future Works

A personalized dynamic assessment system for Linux learning is proposed in this study. The proposed system is divided into three major components, including learning materials, learning resources, and dynamic assessment. The learning materials further consist of six learning modules that are designed according to traditional materials for teaching Linux. The learning resources are technical documents on the Internet; they are classified and aligned according to the six learning modules so that learners can read the documents for the usage of Linux commands. The learning materials and learning resources are designed by professional Linux teachers and are suitable for beginners. To achieve the goal of personalization, dynamic assessment can assess learners' learning states and performance and then provide appropriate learning materials and learning resources as feedbacks to learners. These feedbacks can guide learners to complete the implementation of Apache and FTP server.

The proposed system is now in its prototyping stage. This paper is to describe the issues of planning and design of our system. The processes of expert and user evaluation for the system are also discussed. In the near future, heuristic evaluation by experts and SUS by users will be performed to identify the potential problems of the system. After that, the identified problems must be effectively solved to achieve the goal of truly personalized dynamic assessment.

References

- Black, P., & Wiliam, D. (1998). Inside the black box-raising the standards through classroom assessment. *Phi Delta Kappan*, 92(1), 81-90.
- Black, P., & Wiliam, D. (2009). Developing the theory of formative assessment. *Evaluation and Accountability*, 21(1), 5-31.
- Brooke, J. (1996). SUS-A quick and dirty usability scale, *Usability evaluation in industry* (pp. 189-194). US: CRC Press.
- Campione, J. C., & Brown, A. L. (1987). Linking dynamic assessment with school achievement. In C. S. Lidz (Eds.), *Dynamic assessment: An interactional approach to evaluation learning potential* (pp. 82-155). New York: The Guilford Press.
- Derrich, J., & Ecclestone, K. (2006). Formative assessment in adult literacy, language and numeracy programmes: a literature review for the OECD. Retrieved from <http://www.oecd.org/edu/ceri/37406531.pdf>
- Nielsen, J., & Molich, R. (1990). *Heuristic evaluation of user interface*. CHI '90 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 249-256.
- Stiggins, R. (1992). High quality classroom assessment: What does it really mean? *Educational Measurement: Issues and Practice*, 11(2), 35-39.
- Tsai, D. M. (2010). *Basic learning about Linux OS*. Taiwan: GOTOP.
- Tsai, D. M. (2011). *Server learning about Linux OS*. Taiwan: GOTOP.
- Vygotsky, L. S. (1978). *Mind in society: The development higher psychological process*. Cambridge, MA: Harvard University Press.

Personalized Game-based learning and Mobile learning: The app game “The Adventure of The Ch’ing Dynastry Treasures”

Sheng-Chih CHEN^{a*}, Po-Sheng TIEN^b, Yi-Chin YANG^b, Fu- Hsin PENG^a, Kuan-Ying WU^c,
Wei-Lin CHEN^d, & Yi-Jia HUANG^e

^a Master’s Program in Digital Content’s & Technologies, National Chengchi University, Taipei, Taiwan, ROC

^b Department of Advertising, National Cheng Chi University, Taipei, Taiwan, ROC

^c Doctoral program, Graduate Institute of Architecture, National ChiaoTung University, Hsinchu, Taiwan, ROC

^d Master’s Program, Department of Political Science, National Taiwan University, Taipei, Taiwan, ROC

^e Master’s Program, Department of Business Administration, National Cheng Chi University, Taipei, Taiwan, ROC

* scchen@nccu.edu.tw

Abstract: In this paper, we use images of cultural artifacts on digital content interactive media design and production with research methods as design analysis, user behavior analysis, observation and qualitative research. The process is as follows. The process is as follows. 1. Selecting three to five cultural artifacts for visual element analysis. 2. Transforming and operating images through design thinking. 3. Combining with new communication technologies (mobile device, sensor) to make prototypes.

Keywords: National palace museum, personalized game-based learning, mobile learning, digital game, digital storytelling

1. Introduction

Not only on the level of backend infrastructure, but also technological and new business , plus the government’s promotion, the development of digital content in Taiwan is quite mature and flourishing. Judging from the ways of communication in modern society, design in its many forms has appeared in every part of our lives and is still rapidly changing. Every piece of design has to have interactions with the observer ultimately. Hence the designer has to satisfy his or her own esthetic demand and anticipate observers’ possible reactions at the same time. As a message sent out by the designer, a piece of design also has to show its social value and responsibility. The aim of this study is to use images of some cultural artifacts in National Palace Museum on digital content interactive media design & production, new communication technology and learning effect evaluation. The main purposes are as follows: Using images of cultural artifacts on digital content interactive media design: digitalization, operationalization, applicability.

Due to the rapidly changing of complex situations in the external environment, Mansilla and Gardner (2008) called for today’s educators to reconsider the current teaching methods. In addition to imparting knowledge, the educators should also focus on how to cultivate talented persons to face the future challenges and involve in more research and action. Mansilla and Gardner emphasized that students need to master the method of thinking, so as the ability to imagine and deal with the unknown. With these capabilities, when an individual faces the continuous emerging of complex situations and problems, he/she may not examine the problems with much of linear thinking. In addition to broaden the basis of thinking, a holistic and comprehensive ability is also developed to understand the changing world (Dorsch, 2012; Fettes, 2010).

However, despite the existed achievements in creativity, I deeply know that there are often many uncertainties and unpredictable trials. In the scientific field, people often concern about

"scientific inquiry". In the art field, people emphasis on "incubation". Both of them tries to clarify what happens during the "warm up" phase before creating. They also care about the quality of the experience during the warm up phase, in order to response to the needs of learners more appropriately. In the current learning context, learners often cannot digest and organize the knowledge they receive due to too much of fragmented knowledge. As a result, it might be difficult for the learners to produce creative products. On the other hand, individuals are required to involve in meaningful exploration activities and analyze the relevant affairs before creating. Moreover, they should express the implicit knowledge smoothly by continued practicing, as to boost the renewal and innovation of the original knowledge.

Mobile applications in ubiquitous computing have become diverse and well developed as network environments have improved. The historical and cultural aspects of attraction can typically be best understood when users experience them directly. For mobile users with a limited time to visit, developing a deep connection to a tourist attraction can be difficult. The development of an interactive application for mobile users for this purpose has become a challenge. Currently, many mobile travel services provide mobile users a large amount of information over the Internet, but not many developers consider history and culture in the early stage of development of such services, so as to help tourists experience the features of tourist attractions, or associating the style of the interface with the features of the attraction, for example. With reference to the above goal, this paper introduces "digital humanities" as an area of research that combines the fields of digital technology, history and the humanities (Borgman, 2009).

According to the comprehensive analysis of domestic and international literature in this study, although national programs in many regions have noticed the research value of imagination (Fraser, 2011; Gunnell & Bright 2011; MIT opencourseware, 2007), the relevant research in personnel training mostly focused on "creativity". The empirical research on the impact of imagination towards creation or learning is still insufficient (Leahy & Sweller, 2008, 2011). Therefore, the present study focuses on the learning process of college students. Based on different characteristics, experience, knowledge and background abilities, we should construct a learning model that may effectively guide the persons with different personality traits to stimulate their imagination and bring about their creation. By doing this, more effective teaching model may further be developed and be combined with knowledge of different fields to improve the effectiveness of teaching. Moreover, to assist the learners to develop their own self-guided model that benefit themselves.

The main purpose of this paper is to develop applications of digital humanities for National palace museum, in company with graduate interactive course to teach the students to develop their mobile GAMEs. To explore National palace museum, we took the students there to see artifacts, to experience and learn about the culture and history. Next, the students developed research architectures to design and develop their own mobile services. In this research, students without any prior mobile development experience were allowed to participate in the whole development process, including product planning, field test, and design and implementation of their services.

2. Design Imagination and Curriculum Planning

2.1 Design imagination

International studies of imagination continued to accumulate, which included several trends: (1) to emphasize that imagination is an innate ability of individual mental development. Thus, we should activate this innate ability to assist the individual to respond to the future challenges of complex environment more effectively (Gardner, 2007); (2) Imagination is usually largely associate with non-verbal and imagery thinking. Therefore the individual may link the implicit knowledge with the explicit knowledge, integrate abstract and concrete, and go from the known to the unknown. Imagination plays a whole and synthesis role of thinking (Egan, 2005, 2007; Eisner 2002); (3) Activation of individuals' imagination may bring mental activities such as curiosity, exploration, feelings and intuition. This may lead the individual to start a positive cycle of independent learning (Carrie, 2002); (4) High quality of imagination is the source of creativity. It not only activates the knowledge of the individuals, but also enables them to utilize and innovate the knowledge. However, in order to avoid the stagnation or excessive divergence of individuals' imagination, we should provide

them with appropriate guidance to promote positive development (Chen, Huang, & Liang, 2012 ; Lindqvist, 2003; Leahy & Sweller, 2008, 2010; Vygotsky, 2004).

The features of initialing imagination include inquisitive, innovative, productive, etc (Eckhoff & Urbach, 2008; Folkmann, 2011; O'Connor & Aardema, 2005; Thomas, 1999; Vygotsky, 2004). This means that when individual faces problem situations, if he/she may conduct various imaginary exploration and produce diverse and innovative imagination content, he/she is driven to perform the initialing imagination. Specifically, when individual engages in exploration, he/she uses a variety of senses or thoughts to process free association and combination. By doing this, he/she may bring out a variety of "possibilities". The imagination is considered "novel" when individual captures or generates unprecedented, new and unique ideas. When breakthrough is made to the aforementioned thinking, the imagination with "productive" feature will be created. Thus, the learners' imagination becomes rich and emerges continually. The assembly of the three features—exploration, production and novelty made the concept of imagination more concrete. It also corresponded to the connotation of "creative imagination" which has been discussed internationally.

2.2 Curriculum Planning

This research involved a graduate course called, "Interactive Technology: Media, Perception, & Design". During the eighteen classes, the development of innovative and fancy techniques was not the main concern. Rather, much attention was paid to teaching graduate students with no mobile development experience to implement their own mobile applications. The goal was that the training would enable students to consider the culture, history humanities, and to engage successfully in team works and budget planning. More effort was made herein than in other works to enable students to participate in a complete development process, starting from product planning, field test, design and implementation.

During the course, students were separated by groups to choose a topic and develop a commercial application for mobile devices. The most important part of the design process was the documentation of the process. Every group was required to document their process for subsequent review and examination of their design. Experience of the local culture and interaction with the environment gave the designers the elements required for storytelling.

2.3 Interactive Course and Methodology

The smartphone which is a mobile device rises due two years. User can easy download games quickly by wireless from application market like Android market or app store. It is important for game developers to know which game user chooses and downloads in large games. This research involved a graduate Interactive Technology course. Most students who take this course have no prior mobile development experience. They develop their own mobile application, performing product planning, field test, and the design and implementation of their service. This research is also concerned with the integration of the actual target area with the implementation that is learned in the course. Rather than simply focusing on academic theories and case surveys, this research is highly practical. Students not only need a basic understanding of mobile development, but also consider actual target area engage in teamwork and plan a budget.

Sweeney and Soutar(2001)proposed the following four dimensions of customers' perceived value. 1. Emotional Value: Products that can induce feelings or emotional states. 2. Social Value (enhancement of social self-concept): products that can enhance or reinforce social identity. 3 Perceived Sacrifice: Long-term increase or decrease of the costs in cost owing to use of the products. 4. Functional Value (performance / quality): Desired effect that can be achieved by using of the products. This research considers the relationships among social cognition, social value, and service experience. In experiential learning, the teacher is transformed into an "instructor". Students and instructor learn together during the design process(Chen, Huang, & Liang, 2012).

From theory through implementation to a cultural field to discover experience-oriented problems, the relationship among information technology, digital content and intelligent living is discussed. The main purpose of the course is to integrate interface design and technology with culture to provide solve problems and perform strategic simulations. Through the development of mobile

applications and theoretical analysis as a mediator, interaction between their cognition from real space to virtual space, students may learn and apply the techniques to a domain.

3. Illustrations “The Adventure of The Ch’ing Dynasty Treasures”

The invaluable artistic treasures held inside the National Palace Museum in the Taipei City consists the world’s largest collection of treasure troves from the Sung, Yuan, Ming, and Ch’ing Dynasties, which almost covers the entire 5,000 years of the Chinese civilization. Boasting a collection of over 655,000 pieces of artifacts, the treasures in the National Palace Museum can be generally classified into the categories of bronzes 、calligraphy and painting, ceramics, documents and rare books, art crafts, and palatial treasures. Preservation and collection of the essence of cultural artifacts and arts from the various Chinese dynasties has also gained the National Palace Museum the good name “The Treasure Box of the Chinese Culture”. However, how many pieces of cultural artifacts do you know about among the world’s largest collection of invaluable Chinese artistic treasures in the National Palace Museum?

In view of the latest trend of economic development propelled by the launch of smartphones and phone applications, a game-based application “Mysterious Treasures from the Ch’ing Dynasty- an Adventurous Journey in Search of National Treasures” with profound significance of history education and fun features was designed by our team to re-interpret the historical meaning of cultural artifacts from the Qing Dynasty in the National Palace Museum with a fun concept, in the hope to allow more people to appreciate the history and aesthetics of the Chinese culture in the fun of playing games.



Figure 1. The main screen of the game 「Mysterious Treasures from the Ch’ing Dynasty- an Adventurous Journey in Search of National Treasures」 & The prototype and design of the game “the Ch’ien-lung Emperor travels to Jiang-nan”.

3.1 Concept of Creation

During a period of 33 years, the Ch’ien-lung Emperor in the Ch’ing Dynasty took six surveillance journeys to the Jiang-nan area (the southern area of the Yangtze River, often referring to south Jiangsu, south Anhui and north Zhejiang provinces) to lift taxes and corvée as rewards, oversee river works, observe local officials and civilians 、patronize local gentries, cultivate official families, review troops, and express reverence for the dead at their tombs. The “Routing Atlases of the Ch’ien-lung’ Emperor’s Surveillance Journeys to the South” is the earliest atlases that document the Ch’ien-lung’ Emperor’s surveillance journeys to the south among the collection in the National Palace Museum. The main content of the atlases comprises of the preliminary surveillance routed planned by relevant imperial officials in order to arrange the Majesty to travel southward to the Jiangsu province. In the collection of atlases, each atlas is intertwined with pictures and words, graceful and light shades of colours, as well as simple and elegant composition. Giving a comprehensive and true account of scenes during the surveillance journeys of the Ch’ien-lung Emperor, and reflecting the landscapes and outlooks in that particular historical time, this atlas is popular from the ancient time to the present days. In light of this,

with the inspiration of the “Routing Atlases of the Ch’ien-lung Emperor’s Surveillance Journeys to the South”, design of the secrecy in the game resembles the natural scenery and cultural facets of the Jiangsu province in the “Routing Atlas of the Ch’ien-lung’ Emperor’s Surveillance Journeys to the South”. In addition, to add more fun elements to the game and to promote the historical and cultural artifacts from the Ch’ing Dynasty and the Chinese culture, characters designed based on various cultural artifacts are also placed along the journey in the application, which allows the application users to understand the Chinese culture and experience the virtual scenes of the Ch’ien-lung Emperor’s journey to the Jiang-nan area when playing the game.

To present the Chinese culture in an enjoyable manner, characters in the various barricades of the game are designed based on renowned antiques and cultural artifacts from the Ch’ing Dynasty. For example, the “Jade Bear Figurine from the reign of the Ch’ien-lung Emperor in the Ch’ing Dynasty” was used to brainstorm the characters in the game, and a story concept involving Jadeite Cabbage, a classic National Palace Museum collection, is incorporated into the application to enable application users (game players) to have better comprehension of cultural artifacts through playing around with the shapes of the cultural artifacts in the various selection of the little games. In addition, the concept of “multiple slots for treasures” from the masterpiece “Engraved Sandalwood Multiple Slots Square Treasure Box” is used to design the activity of collecting cultural artifacts in the game. Inside the “multiple slots for treasures”, there are national treasure dolls of the National Palace Museum which are rewarded to game players as they breakthrough each barricade of the game. Further, a description of the history and culture of these national treasure cultural artifacts is given to gradually guide game players to know each cultural artifact in the National Palace Museum.

In this game, players can collect multifarious cultural artifacts and understand the historical significance of these artifacts during the course of breaking through each barricade of the game. With adorable design of each character, user-friendly touchscreen, and interesting activities, the application allows users at different ages to happily enjoy the game. In addition, the most important feature of the application is that cultural background is incorporated into the game, which allows players to boost their knowledge at play, and makes the game a helpful assistance in providing education through fun activities, instead of being an ordinary game.

3.2 Design of Icon

The “Meat-shaped Stone”, which is a palatial curio in the Ch’ing Dynasty, was originally a naturally-formed agate, which during the process of formation was infused with impure elements from the exterior world that resulted in its strata of different colors resembling a piece of incredibly lifelike pork cooked in soy sauce and it name “Meat-shaped Stone”. Currently, the Meat-shaped Stone and the Jadeite Cabbage are listed together as important artifacts among the collection of the National Palace Museum.



Figure 2. Icon design—“tiny stone”.

As the Meat-shaped Stone has become an important artifact in the National Palace Museum collection and has been well-known by the public, it is chosen as the prototype for designing the icon of the

application for the purpose of accurately linking the cognition of the public, promoting the National Palace Museum collection pertaining to the Ch'ien-lung Emperor in, and further exhibiting a fresh outlook of incorporating the classic cultural artifacts in the National Palace Museum with new technology. Besides, a “tiny stone” piggy character is designed based on the form and features of the Meat-shaped Stone to symbolize a fusion of the profound historical meaning of the National Palace Museum and the entertaining feature of the application(Figure 2).

4. Character Introduction and Inspirations

4.1 Character Introductions

Wen-Xiong: Inspired by the Bear-Shaped Jade Zun, this character is smart and erudite. He likes picking herbs in the mountains and writing poems and wants be doctor. A very good friend of Emperor Ch'ien-lung. Princess Cui-Cui: Inspired by the famous Jade Cabbage, this character is the princess of the Cabbage Kingdom. A shy and timid girl, she has two pets, a locust and a grasshopper. She enjoys hot baths to refresh herself(Figure 3).

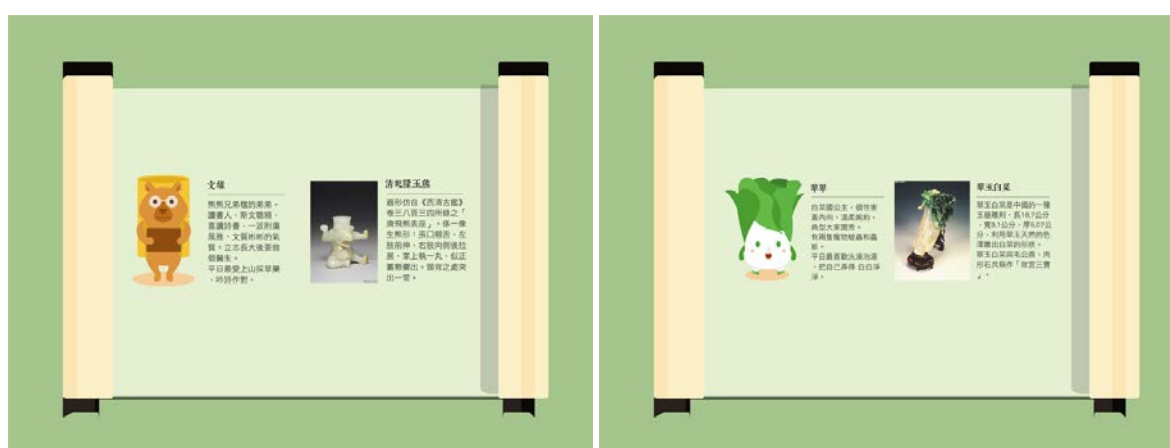


Figure 3. Wen-Xiong & Princess Cui-Cui.

4.2 Game Inspirations

4.2.1 Emperor Ch'ien-lung's Travel

The ideas for this game came from “The map of Emperor Ch'ien-lung's trip to the south” and the “Bear-Shaped Jade Zun”. The story goes like this: The emperor invited the knowledgeable bear “Wen-Xiong” to go on a trip along the river with him. The bear is not only erudite for he's the one who introduced the scenic spots along the river to the emperor, but had keen eyesight to steer the ship away from the dangers in the water. With this simple ship-steering game, we hope to sharpen toddlers' visual skills and sense of direction.

4.2.2 Exterminate the Pests!

Cabbage Princess Cui-cui wanted to do something for her own country and so she decided to kill the pests in the garden. Similar to the traditional whac-a-mole, this simple and fun game was added a twist, there are bugs not to be killed. This is hoped to reinforce toddlers' color and shape learning and eye-hand coordination.

5. How to operate the app?

“The adventure of the The Ch’ing Dynasty Treasures” is an educative and interactive mobile game, which not only provides fun but also helps improve toddlers’ eye-hand coordination. Children can learn about ancient Chinese artifacts and their history in the process as well. The Curio Box system used in the app allows the user to tap and learn.

5.1 Basic Operations

For convenience and simplicity, users can either use their finger or a stylus pen. By opening the app, one is in the main menu. There are two options, “start game” or “the curio box” (Figure 4). From the main menu, select “The Curio Box”. Then select any icons to learn more details about the particular artifact. By selecting “start game” in the main menu, the map appears. If tapping on “Wen-Xiong”, one will be taken to the game of “Emperor Ch’ien-lung’s travel”. If choosing “Princess Cui-Cui”, one will be taken to the game of “Exterminate the pests!” The rules of “Emperor Ch’ien-lung’s Travel”: The point of this game is to steer the boat without hitting the obstacles like rocks or rapids in the river. Players are allowed three chances. The Rules of “Exterminate the pests!”: The point of this game is to exterminate as many pests as possible appearing in the cabbages within one minute. But the grasshopper and the locust have to be avoided because they are the princess’s babies. Users can use either their finger or a stylus pen. The bar at the top shows how many points you’re winning so far(Figure 5).



Figure 4. The Map & A Screenshot of “Emperor Ch’ien-lung’s Travel”.

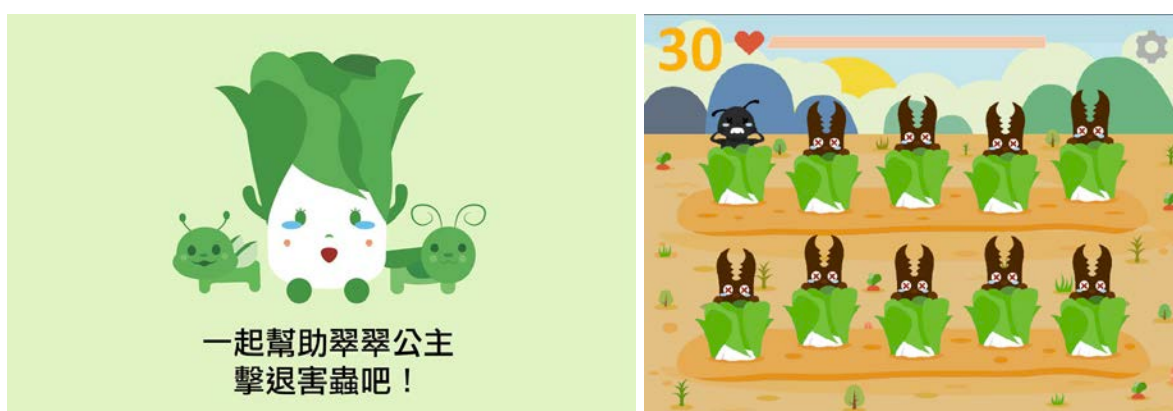


Figure 5. A Screenshot of “Princess Cui-Cui”.

6. Conclusion

This study aimed at firstly developing an app game with the inspiration of Chinese artifacts, and secondly, developing a curriculum that can improve design imagination and enhance design ability. Students taking this course will be able to cultivate digital skills for interdisciplinary applications. As we can be sure that the personalized game-based learning and mobile learning aren’t something to fade

fast, we hope our curriculum can inspire a new generation of app designers. With the rapid development of information communication technology, the capacity of mobile computing and the quality of network connection have been improved. The abundance of mobile applications can help people to complete more tasks than ever before. This research considers mobile devices as interfaces for presenting content. The computing resources of mobile devices have not yet been used not system evaluation or modification performed. A standalone mobile travel application is useful when the quality of the network connection is poor, but the amount of information delivered must be drastically reduced.

We hope to develop more diverse functions in the future, and provide more customized services for mobile visitors. Finally, the students who participated in this research were deeply involved in the whole development process. We hope that the products developed herein will be commercialized in the near future.

Acknowledgements

This research was supported by the National Science Council of Taiwan under contract No. NSC 102-2420-H-004-005-MY2. The authors would like to thank Professor Rua-Huan Tsaih. We are also grateful to three TAs, Pei-chun, Tsai, Chi-Ping, Chin and Janet, Huang. We also wish to thank all of the participants in the experiments.

References

- Borgman, C. L. (2009). The digital future is now: A call to action for the humanities, *Digital humanities quarterly*, vol. 3, no. 4.
- Chen, S. -C., Huang, Y., & Liang, C. (2012). The combined effects of learning environment and personality traits on student imagination. *Instructional Technology and Media*, 102, 62-78.
- Dorsch, F. (2012). *Experience and introspection*. In F. Macpherson & D. Platchias (Eds.), *Hallucination*. Cambridge (Mass.): MIT press.
- Eckhoff, A., & Urbach, J. (2008). Understanding imaginative thinking during childhood: Socio-cultural conceptions of creativity and imaginative thought. *Early Childhood Educational Journal*, 36, 179-185
- Egan, K. (2005). *Engaging imagination and developing creativity in education*. Newcastle, UK: Cambridge Scholars.
- Egan, K. (2007) Imagination, past and present. In K. Egan, M. Stout, & K. Takaya (Eds.), *Teaching and learning outside the box Inspiring imagination across the curriculum*. New York, NY: Teachers College Press.
- Eisner, E. W. (2002). *The art and the creation of mind*. London, UK: Yale University Press.
- Fettes, M. (2010). The TIEs that bind: How imagination grasps the world. In K. Egan & K. Madej (Eds.), *Engaging imagination and developing creativity in education*. Newcastle, UK: British Library Cataloguing.
- Folkman, M. N. (2011). Spaces of possibility: The imaginary in design. *The design Journal*, 14, 263-282.
- Gardner, H. (2007). *Five minds for future*. Cambridge, MA: Harvard Business.
- Gunnell, B., & Bright, M. (2011). *Make a job, don't take a job: Building the creative society*. London, UK: Ndotm.
- Leahy, W., & Sweller, J. (2008). The imagination effect increases with an increased intrinsic cognitive load. *Applied Cognitive Psychology*, 22, 273-283.
- Leahy, W., & Sweller, J. (2011). Cognitive load theory, modality of presentation and the transient information effect. *Applied Cognitive Psychology*, 25, 943-951.
- Lindqvist, G. (2003). Vygotsky's theory of creativity. *Creativity Research Journal*, 15, 245-251.
- Mansilla, V. B., & Gardner, H. (2008). Disciplining the mind. *Educational Leadership*, 65, 14-19.
- MITopencourseware. (2007). *Writing on contemporary issues: Imagining the future*. Retrieved January 25, 2012 from <http://ocw.mit.edu/courses/writing-and-humanistic-studies/21w-730-5-writing-on-contemporary-issues-imagining-the-future-fall-2007/assignments/profile.pdf>
- O'Connor, K. P., & Aardema, P. (2005). The imagination: Cognitive, pre-cognitive, and meta-cognitive aspects. *Consciousness and Cognition*, 14, 233-256.
- Sweeney, J. C. and Soutar, G. N. (2001). Consumer perceived value: the development of a multiple item scale, *Journal of retailing*, vol. 77, no. 2, 203-220.
- Thomas, N. J. T. (1999). Are theories of imagery theories of imagination? An active perception approach to conscious mental content. *Cognitive Science*, 23, 207-245.
- Vygotsky, L. S. (2004). Imagination and creativity in childhood. *Journal of Russian and East European Psychology*, 42, 7-97.

Learning Experience of Game Poetry: A New Approach for Poetry Education

Hsin-Yi LIANG & Sherry Y. CHEN*

Graduate Institute of Network Learning Technology National Central University Zhongli, Taiwan

* sherry@cl.ncu.edu.tw

Abstract: Poetry is a creative language which enhances imagination and self-reflection. However, the ambiguity of poetry increased the difficulty in interpretation, which builds students' negative learning perception and demotivates most students to read poetry. Previous research implied the positive relationship between the ease of interpretation and learning perception. Besides, many studies showed the positive effect of active participation on interpretation. Meanwhile, game is able to improve the interpretation by rich feedback and narratives. Previous research also suggested game-based learning positively improves students' learning perception and motivation. To the end, this study develops a game-based learning system for students. Both quantitative and qualitative analyses are applied to evaluate the improvements of students' perception. Besides, Spearman's correlation was applied to explain the relationships among learning perceptions, such as interpretation, active participation, and playfulness. The results argued active participation was significantly related to interpretation. However, the improved attraction was positively related to students' participation, interpretation, and learning perception.

Keywords: Game-based learning, poetry, user perception, interpretation.

1. Introduction

Many literature workers believe poetry is a creative language which is able to provoke reflection of the self and society (Wainwright, 2004). However, the ambiguity of poetry increases the difficulties for students to interpret the enjoyment of poetry. In other words, the difficulties of interpretation build students' negative perception of poetry and in turn demotivate them to read poetry. Therefore, the interpretation of poetry positively affects learning perceptions (Hill & Newall, 2004). To improve students' perception and motivation, the interpretation needs to be highlighted. However, some studies argued the effectiveness to improve the interpretation in traditional learning (TL). That is, in a TL context, students passively listen to the explanations without active interpretation of poetry, which limits the effects to improve students' interpretative skills of poetry (Siemens & Schreibman, 2008).

Meanwhile, game-based learning (GBL) shows positive effect on learning. Many studies indicate GBL significantly improve students' participation and learning performance (Hwang, Wu, & Chen, 2012). GBL provides rich and clear feedback to support student learning in a flexible environment. In other words, the freedom and rich interactions of GBL attract students to learn actively (Bleumers, All, & Marien, 2012). Moreover, the playfulness of GBL also strongly improves students' learning perception and motivation (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012). Previous research indicates GBL can enhance students' self-efficacy, which improves students' frustration in learning and their negative perceptions of the specific subjects, such as health management and public participation (Bleumers et al., 2012). Due to the aforementioned benefits, GBL is considered as useful learning tools, which have potential to improve students' interpretation, active participation, and perceptions to interpret poetry.

To the end, this study develops a GBL system for students. To examine the improvement of active participation, interpretation and negative perceptions of learning poetry, students' subjective feedback was examined by comparing the learning effectiveness of the traditional and game-based learning. Moreover, spearman's correlation was applied to analyse the relationships among learning perceptions, such as active participation, interpretation, and playfulness. In brief, this study attempts to find answers for the following two research questions:

- (a) How GBL improve learning perceptions of poetry in the context of GBL?
- (b) What are the relationships among learning perceptions in the context of GBL?

2. Methodology

2.1 System Design of the Game-based Learning System: Skysea

A game-based learning system named Skysea was developed to present “The interpretation of digital poetry” for university students. To improve the active participation, interpretation, and negative perception of poetry, the GBL was designed as a 2D side-scrolling Action Role-Playing Game (ARPG). In other words, this GBL includes two characteristics: action game and role playing qualities. More specifically, ARPG was able to demonstrate both of the interactive and linguistic qualities of digital poetry (Figure 1). Moreover, the immediate feedback and rich interactions of action game were able to improve the playfulness and student’s immersion in gaming, while the simulative narratives of role-playing qualities were able to help students interpret poems(Ryan, 2009; Wolf, 2006).



Figure 1. The game design to present linguistic (left) and interactive (right) qualities of digital poetry.

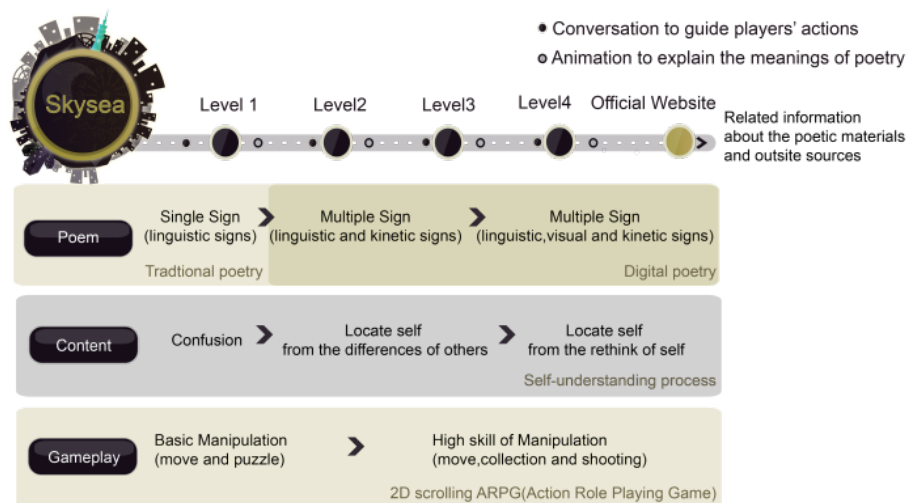


Figure 2. The design model of Skysea.

Figure 2 displays the design model of this system which covers the aforesaid aspects. Regarding the improvement of active participation, the active interpretation of poetry was considered as the key to clear each level. For example, a short poem was applied as the level goal and students had to interpret the meanings of the poem to clear the level (Figure 3). In this way, it was less possible for students to skip the poems while gaming. Therefore, students were able to practice their interpretation skills of poetry.



Figure 3. The poem as level goal of level 2 in Skysea.

Regarding the improvement of interpretation, the level design focused on the two aspects of improvement. One is to develop students' interpretative skills while the other is to improve the ease of understanding. To improve students' interpretative skills of poetry, each level was designed as a digital poem written from single (i.e., the linguistic signs) to multiple sign systems (i.e., the linguistic signs plus the visual and kinetic signs). By doing so, students were able to learn poetry from the familiar linguistic form to the digital form of poetry, and they were able to develop their understanding of digital poetry during the process of playing the GBL.

Regarding the improvement of ease of interpretation, the simulative narratives were able to guide students to interpret the meanings of poetry by themselves (Rutten, van Joolingen, & van der Veen, Jan T, 2012). More specifically, there are both conversation and animation to translate the meanings of each poem, which facilitate students to understand the meanings of each level without direct explanations to limit their imagination (Figure 4). Therefore, this design provided students with the flexibilities to rethink and learn the other concepts from their interpretation of this game (Yevin, 2006).

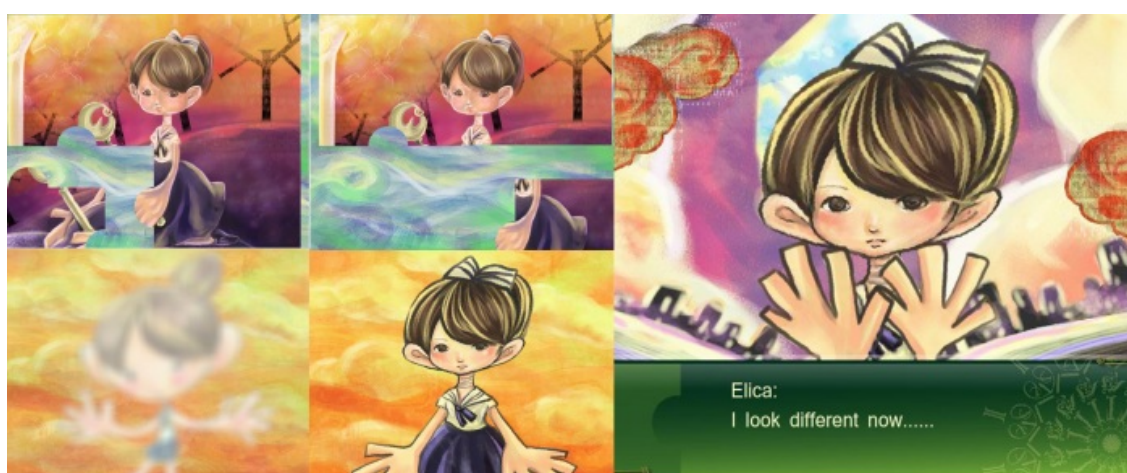


Figure 4. The animation and conversation to support students' interpretation of poems in Skysea.

Moreover, previous studies suggested the wrong selections of poems which described the unfamiliar experience from students' life experiences may increase the difficulty to interpret poetry. Hence, the poems of this game were selected to match to students' life experiences (Hughes, 2008).

Regarding the improvement of negative perception of learning poetry, previous studies suggested the fruitful narratives and interactions were able to improve the playfulness (Rutten et al., 2012; Wolf, 2006). More specifically, the storytelling of indirect explanation of poems can evoke students' creativity and indeed they are able to gain more fun from the different views of interpretation (Yevin, 2006). Regarding the interaction design, many game designers indicated that there is a need to provide students with various choices and surprises so that the playfulness of learning poetry can be promoted (Schell, 2008). Therefore, Skysea supplied a variety of qualities of gameplay in each level. For example, a puzzle was put into the first level as a code door, and the collection and other qualities were applied in the next levels (Figure 1). Besides, the rich feedback and stimulus, such as visual and sonant effects were also provided to attract students (McDougall & O'Brien, 2008).

2.2 Experiment Design

2.2.1 Research Model

To find the answers for the two research questions described in Section 1, an experiment was conducted to evaluate the GBL system: Skysea. Figure 5 displays the research model of this study. More specifically, the comparison of learning preferences, performance, and effectiveness between TL and GBL were conducted. Students' subjective feedback was categorized and was analysed to examine the relationships among these categories.



Figure 5. The research model of this study.

2.2.2 Research Instruments

Two questionnaires were employed in this study. The first questionnaire was used to identify students' basic information, such as age and gender. The second questionnaire included three open-ended questions, which were employed to assess their subjective feedback to compare the learning effectiveness between TL and GBL.

The learning effectiveness was assessed from preferences, perceptions and performance. , Students' had to compare the learning preference, performance, and perceptions between TL and GBL, and they had to provide the reasons for their choices.

2.2.3 Experiment Procedure

A total of 30 graduate students from the National Central University in Taiwan participated in this experiment. The participants included 20 male and ten female non-poetry readers, and they did not have any experience and understandings of digital poetry. However, these students had the basic understandings of poetry and computing skills necessary to play a GBL system.

Regarding the experiment procedure, the participants were asked to complete a questionnaire to describe their basic information in the beginning. After they completed the questionnaire, they had to play the GBL and clear all the levels. After they finished playing the game, they were requested to complete another questionnaire to assess their subjective feedback. The total time for the experiment was about 60-80 minutes.

2.2.4 Data Analysis

To understand whether the GBL improves the interpretation and perceptions of poetry, students' subjective feedback was analysed in a quantitative way. In addition, the students' responses were examined in a qualitative approach to identify the differences between GBL and TL. To understand the strengths and weaknesses of GBL, students' feedback was categorized based on their similarities. Furthermore, these categorized data were analysed by spearman's correlation to identify the relationships among various dimensions of perceptions.

3. Results and Discussions

The quantitative result shows most students (N=21) preferred to learn poetry by GBL, instead of neutral (N=7) or TL (N=2). Table 1 displays the strengths and design issues of GBL. Figure 6 demonstrates the relationship among these categories. As shown in Figure 6, the improvements and relationships among learning perceptions will be discussed from three aspects, participation, interpretation of poetry, and learning perceptions. Indeed, the influences of design issues on each aspect will be also discussed in the follow sections.

3.1 Active participation in learning

As shown in Table 1, GBL strongly improved the active participation of student learning (N=17). Many students (N=16) considered that the GBL provides a simulative experience by providing both visual and sound attractions, which enhances their immersion to play the GBL ($p < 0.05$). In other words, the GBL positively affects students' immersion to make them take an active way for their learning. Therefore, this result demonstrates the positive influences of visual and auditory presence on students' active participation. This result also supports the previous research, which indicated that presence positively affects the active participation (Hou, Nam, Peng, & Lee, 2012).

Besides, a positive relationship exists between active participation and freedom of choices ($p < 0.01$). Some students (N=12) mentioned that the GBL provides freedom of choices to explore the meanings of poetry, which enhances their controllability in learning. Indeed, the improvement of empowerment encouraged them to have positive engagement. The result supports the positive effect of empowerment in students' active participation (Bleumers et al., 2012). In turn, the improved attractions and participation also improved students' impression of poetry (N=13). For example, a male student (No.27) explained the active participation helped him understand the poetic experiences of poetry, and indeed the gaming experience was able to help him memorize the content of poetry. Another female student (No.15) also described the various visual and sonant effects enhanced her impression of poetry. Moreover, she was able to understand the poems better through gaming. Such results implies the positive relationships among active participation, attraction, and impression ($p < 0.05$). Besides, there is a positive relationship between clear learning focus and active participation ($p < 0.01$). This may be due to the fact that the clear goal and feedback can reduce students' confusion so that they are able to immerse into the game better (Adams, 2010). Therefore, to improve the active participation, there is a need to provide clear goals and feedback to prevent disorientation in GBL.

Although previous studies believed there was a positive effect of active participation on learning performance, there was no significant relationship between interpretation and active participation in this study ($p > 0.05$). This may be due to several design issues. Firstly, some students indicated the improved attraction enhanced their participation in gaming, however, the unclear learning focus (N=2) or improper matched content and gameplay (N=7) influenced their learning performance. Moreover, few students (N=4) complained the manipulative difficulties made them be unable to focus on the learning content while gaming. Thus, they hardly improved their interpretive skills during the process of the participation. The aforementioned results suggest that the proper gameplay and challenges should be considered in GBL design to improve the learning effectiveness (Kiili, 2005).

3.2 The Interpretation of Poetry

Regarding the interpretation of poetry, GBL slightly improved students' interpretative skill of poetry and the ease of interpretation by providing simulative attractions and rich feedback (N=14). Regarding the ease of interpretation, many students (N=14) explained they are easier to infer the meanings of poetry through the simulative experience in the GBL. In particular, GBL provides fruitful visual and sonant narratives for them to interpret poetry, which helps them imagine the poetic experience and understand the meanings of poems. Previous studies also suggested simulative experiences enhanced students' empowerment and reflection in the learning-by-doing process, which, in turn, could improve the motivation and interpretation of concepts (Tao, Yeh, & Hung, 2012). Therefore, the results implies the positive effect of simulative attractions on the ease of interpretation ($p<0.05$), and impressions ($p<0.01$).

There is another reason to explain the positive effect of simulative attractions on the ease of interpretation and impression. That is, according to the visual communication theory proposed by Jamieson (2007), the visual and sonant attractions communicate more instinctively and are easier to be recognized than the linguistic signs. For example, a female student (No. 5) explained she were able to understand the poetic experience better through the visual narratives and music. However, she hardly interpreted the poetic experiences from the linguistic signs in the TL context. To the end, it was less possible for her to memorize the content due to the lack of interpretation. Such results address the positive effect of visual attractions on the ease of interpretation and impression. Besides, there are also the positive relationship between ease of interpretation and impression ($p<0.01$). Hence, there is a need to provide proper visual attractions to improve the ease of interpretation so that their impression can be enhanced.

Regarding the interpretative skills, there are the positive relationships among interpretative skills, playfulness, attraction, ease of interpretation, and impression ($p<0.01$). Many students (N=14) believed they were able to improve their interpretative skills of poetry better through the gaming process. In particular, the fruitful feedback of the simulative attractions and interactions were able to help students interpret poetry, which, in turn, supported students to build their interpretative skills. For instance, a female student (No.1) described she could interpret the poetic experiences directly through the gaming process because the attractions and interactions were able to provide her with immediate feedback to improve her interpretation. Another female student (No.29) explained the passive learning in the TL context was less attractive. Therefore, she was easier to lose concentration in learning and hardly improved the interpretative skills of poetry. Conversely, the playfulness of GBL could improve the immersion in learning and in turn build her interpretative skills better. To the end, the playfulness and attractions of GBL are able to build students' interpretative skills neutrally.

In brief, the aforementioned results demonstrate GBL improved both ease of interpretation and the interpretative skills of poetry through the rich feedback and simulative narratives. However, there is a negative relationship between attraction and freedom of imagination ($p<0.01$). A male student (No.6) explained the simulative attractions might limit students' freedom of imagination, which influenced the enjoyments of interpretation. Therefore, he did not prefer GBL because the simulation limited the other possibilities of interpretations in poetry. To the end, there is a need to consider students' different preferences while providing simulative experience.

3.3 The Perceptions of Poetry

Regarding the improvements of negative perceptions of poetry, GBL strongly improved the negative perceptions that poetry is joyless and hard-understanding. As shown in the previous section 3.2, many students confirmed the positive effect of GBL to improve the interpretation of poetry. Regarding the enjoyment, Over the half of students (N=16) described the gameplay and visual attractions improved the playfulness of learning, which enhanced their motivation to interpret poetry. A male student (No.14) described he was attracted to interpret poetry by the rich interactions and various surprises of game. Furthermore, GBL also provided an entertaining environment with less tension on learning. Such "learning through playing" process attracted students interpreting poetry in a natural way. Therefore, many students preferred the positive learning experience from GBL when compared with the traditional approach.

To examine the improvement of playfulness in GBL, our results also find a positive relationship among playfulness, attraction, and interpretative skills ($p<0.01$). Besides, there is a negative

relationship between playfulness and lack of clear learning focus ($p < 0.05$). Previous studies indicated the lack of learning focus may make students feel confused, and such confusion negatively affects students' perceptions and learning performance (Webster & Ahuja, 2006). Hence, to improve the perceptions and interpretative skills of poetry, there is a need to provide students with clear learning focus to guide their actions.

Regarding the positive relationship between attraction and playfulness, many students ($N=16$) described the fruitful stimulus and interactions not only attracted them, but also enhanced the enjoyments in learning. These findings are coherent with those of previous studies, which showed the positive effect of rich stimulus and various gameplays on the satisfactions of enjoyments (McDougall & O'Brien, 2008). Therefore, to improve the positive perceptions of GBL, there is a need to provide sufficient attractions to satisfy students.

Table 1: The strengths and design issues of Skysea.

Game-based learning ($N=21$)	
Strengths	Improve playfulness ($N=17$)
	Active participation ($N=17$)
	Rich interaction ($N=17$)
	Freedom of choices ($N=12$)
	Improvement of controllability ($N=12$)
	Improve attraction ($N=16$)
	Improve immersion ($N=16$)
	Improve interpretation skill ($N=14$)
	Ease of understanding ($N=14$)
	Easy to memorize ($N=13$)
Design issues	Lack of clear learning focus ($N=2$)
	Lack of freedom of imagination ($N=1$)
	Content should be matched to gameplay ($N=7$)
	Manipulation Difficulty ($N=4$)
	Consider the qualities of target audience ($N=2$)
	Lack of Human interaction ($N=1$)

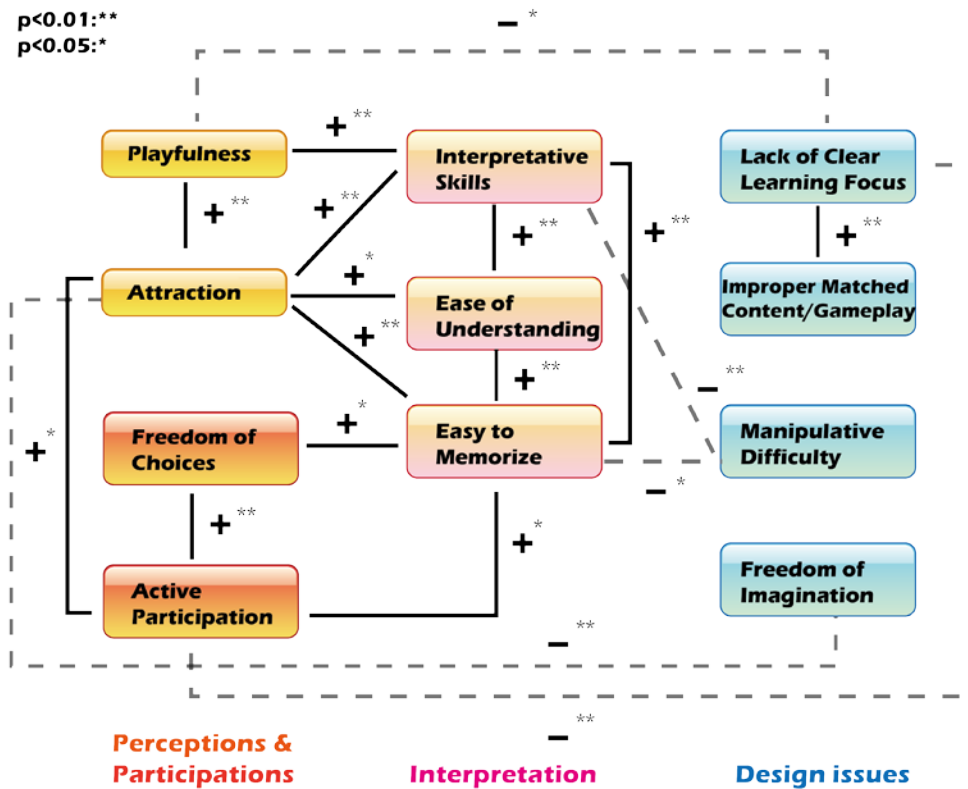


Figure 6. The relationships among subjective feedback.

4. Conclusions

In this study, a game-based learning system named Skysea was designed to motivate students interpret poetry. Regarding the first research question, GBL significantly encouraged students' active participation through the interactive visual attractions and improved playfulness. Besides, GBL also improved the ease of interpretation, interpretative skills, and perceptions of poetry through the rich gameplay and simulative attractions. However, few students did not like the simulative application because simulation limited the other possibilities of imaginations in the interpretation of poetry. To the end, the limitation of imagination should be considered in the application of simulation on learning.

Regarding the second research question, there are the positive relationship among attraction, active participation, playfulness, and interpretation. Hence, attractions have the positive effects on both interpretation and perceptions. Moreover, the unclear learning focus may make students experience disorientation problems, which, in turn, increased their negative perceptions. To the end, to improve interpretation and perceptions of poetry, the GBL design should consider how to attract and satisfy students with different needs (Chen & Macredie, 2010).

Acknowledgements

We would like to thank all the people who prepared and revised previous versions of this document.

References

- Adams, E. (2010). *Fundamentals of game design*. Berkeley: New Riders.
- Bleumers, L., All, A., & Marien, I. e. a. (2012). In Stewart S. (Ed.), *State of play of digital games for empowerment and inclusion: A review of the literature and empirical cases*. Luxembourg: Publications Office of the European Union.

- Chen, S. Y., & Macredie, R. (2010). Web-based interaction: A review of three important human factors. *International Journal of Information Management*, 30(5), 379-387.
- Connolly, T. M., Boyle, E. A., MacArthur, E., Hainey, T., & Boyle, J. M. (2012). A systematic literature review of empirical evidence on computer games and serious games. *Computers & Education*, 59(2), 661-686.
- Hill, W. Y., & Newall, J. (2004). "I don't think poetry has anything to do with accounting" and "Changes":(A teaching note and a poem). *Critical Perspectives on Accounting*, 15(4), 649-654.
- Hou, J., Nam, Y., Peng, W., & Lee, K. M. (2012). Effects of screen size, viewing angle, and players' immersion tendencies on game experience. *Computers in Human Behavior*, 28(2), 617-623.
- Hughes, J. (2008). The 'screen-size' art: Using digital media to perform poetry. *English in Education*, 42(2), 148-164.
- Hwang, G. J., Wu, P. H., & Chen, C. C. (2012). An online game approach for improving students' learning performance in web-based problem-solving activities. *Computers & Education*, 59(4), 1246-1256.
- Jamieson, G. H. (2007). *Visual communication: More than meets the eye*. Bristol: Intellect.
- Kiili, K. (2005). Digital game-based learning: Towards an experiential gaming model. *Internet and Higher Education*, 8(1), 13-24.
- McDougall, J., & O'Brien, W. (2008). *Studying videogames*. Poland: Auteur.
- Rutten, N., van Joolingen, W. R., & van der Veen, Jan T. (2012). The learning effects of computer simulations in science education. *Computers & Education*, 58(1), 136-153.
- Ryan, M. (2009). From narrative games to playable stories toward a poetics of interactive narrative. *StoryWorlds: A Journal of Narrative Studies*, 1(1), 43-59.
- Schell, J. (2008). *The art of game design: A book of lenses*. Burlington: Morgan Kaufmann Pub.
- Siemens, R., & Schreibman, S. (2008). *A companion to digital literary studies: Blackwell companions to literature and culture*. Oxford: Blackwell.
- Tao, Y., Yeh, C. R., & Hung, K. C. (2012). Effects of the heterogeneity of game complexity and user population in learning performance of business simulation games. *Computers & Education*, 59(4), 1350-1360.
- Webster, J., & Ahuja, J. S. (2006). Enhancing the design of web navigation systems: The influence of user disorientation on engagement and performance. *MIS Quarterly*, 30(3), 661-678.
- Wolf, M. J. (2006). Assessing interactivity in video game design. *Mechademia*, 1(1), 78-85.
- Yevin, I. (2006). Ambiguity in art. *Complexus*, 3(1-3), 74.

Students' Motivation of Science Learning in Integrated Computer-based Laboratory Environment

Niwat SRISAWASDI^{a*}, Rungtiwa MOONSARA^b & Patcharin PANJABUREE^c

^a*Faculty of Education, Khon Kaen University, Thailand*

^b*Nampongsuksa School, Thailand*

^c*Institute for Innovative Learning, Mahidol University, Thailand*

*niwsri@kku.ac.th

Abstract: Absolutely, teaching of science by the way of memorizing of scientific facts, what science is, and how to do science is not work for motivating student into meaningful learning in science and understanding science in the way it is. Currently, computerized technological tool is so commonplace in the practice and advancement of science education community in order to engaging student learning in science by doing, not memorizing it. The tool has been proved its potential support in instructional sciences in science classroom. According to the potential abovementioned, this paper reported an effect of integrated computer-based laboratory environment, a harmonization of hands-on computer-based experiment and interactive computer simulation, on 123 of 11th grade students in three groups: 49 science-major students; 37 technology-focused non-science students; and 37 language-focused non-science students. On a purpose, the study has implemented a series of open-inquiry science learning activity in a unit of science of fluid such as capillary action, surface tension and contact angle phenomena. The Science Motivation Questionnaire II (Glynn et al., 2011), was used to investigate their motivation toward learning of science. Results show the learning environment impacted a movement of the students' motivation toward learning of science. This implied that the teaching of science by Integrated Computer-based Laboratory Environment could be used to motivate potentially student learning in science both science and non-science major in secondary education.

Keywords: Computer simulation, hands-on experiment, inquiry, motivation

1. Introduction

Most of high school students in science courses find the subject boring, difficult and generally unnecessary for their living and future, especially for non-science-oriented careers. Traditionally, students are emphasized to develop the accumulation of propositional knowledge, correct explanation, and scientific skills, that it increasingly seen as an inadequate basis for future study and it is also inappropriate basis for developing of scientific literacy (Gilbert, 2006; Srisawasdi & Suits, 2012). Moreover, students are taught with isolated facts and they cannot form the connection of them and science teachers usually deliver the science in a manner of uninteresting thing to the student (Gilbert, 2006). This situation might provide student lack of transfer what they learned and none sense of why they should learn. Otherwise, there was traditional scientific knowledge instead of contemporary knowledge of science. The scientific knowledge was often only simple demonstrations of previously presented scientific facts. These facts do not present authentic scientific investigation to students and often rely on topics and experiments that are distant from authentic scientific inquiry in the contemporary research laboratory. As a result, students may not obtain actual valuable scientific experience from inquiry processes, and in reality, may appreciate science as a foreign thing because they cannot relate to socio-cultural, economic milieu surrounding, and particular important of scientific problems (Srisawasdi, Kerdcharoen & Suits, 2008; Srisawasdi, 2012a). Many researchers feel that this difficulty stems from the passive role the students play in a traditional class (Zoller, 2000). Absolutely, teaching of science by the way of memorizing of scientific facts, what science is, and how to do science

is not work for motivating student into meaningful learning in science and understanding science in the way it is. If this is the case, then we must clearly modify the way we teach in order to develop students who are enthused about science and who really understand the material. Even students headed for non-science-oriented careers need to have an understanding and appreciation of the role science plays in their lives.

It is widely agreed that in order to achieve this end, science teaching must be shifted from traditional schooling to more constructivist-oriented instruction. Inquiry-based learning is a constructivist-informed approach process which is concerned about the cognitive development of the learner and constructivist ideas of nature of science. Inquiry learning has its origins in the practices of scientific inquiry and places a heavy emphasis on posing questions about the natural world, investigating the phenomena by gathering and analyzing data, and constructing evidence-based arguments in order to develop a rich understanding of concepts, models, theories, and principles (Krajcik & Blumenfeld, 2006; Kuhn, Black, Keselman & Kaplan, 2000) as a set of interrelated processes. Currently, computerized technological tool is so commonplace in the practice and advancement of inquiry-based science education in order to engaging student learning in science by doing, not memorizing it. The tool has been proved its potential support in instructional sciences in science classroom. Computer technologies are receiving increased attention from the science education community because of excitement about their potential to support new forms of teaching and learning and computerized classroom learning environments have the potential to overcome the management difficulties normally associated with inquiry-based learning and constructivist teaching. They can help transform the science classroom into a learning environment where students are engaged with its facilitation to actively construct deep understanding of science concepts and process through inquiry (Tinker & Papert, 1989; Linn, 1998; Novak & Krajick, 2006).

In this paper, we illustrate innovative computer-based instructional materials that have been developed from scientific laboratory research related to the field of contemporary scientific knowledge production such as self-cleaning surface and also report a result on the use of integrated computerized laboratory environment for promoting student's science motivation, both science major and non-science major secondary school student.

2. Technology-enhanced Inquiry in Science

The use, of technologies, held great promise for school science education and it was seen as an increasingly high educational priority (Thomas, 2001). As an instructional approach, modern technologies had become commonplace, in the integration of inquiry within the science classroom (Songer, 1998). The crucial idea, in promoting the students' involvement in the potential of scientific inquiry, was the use of technology to support their active inquiry. The use, of technological tools, was intended to facilitate learning and could advance teaching and learning tremendously (Waight & Abd-El-Khalick, 2007). Kim, Hannafin and Bryan (2007) guided the use of technology as a learning tool towards enhancing students learning science through inquiry. They emphasized that the tool should (1) support mindful investigations; (2) serve as meta-cognitive scaffold for building and revising scientific understanding; and (3) facilitate collaborative construction of scientific knowledge.

Engaging learners into more flexible of scientific inquiry through conducting computer-based laboratory experiment is more emphasizing in recent science education (Srisawasdi, 2012b, 2012c). Therefore, science teachers who have a critical role in implementing inquiry-based learning, especially in case of open-ended inquiry, need to know and practice to build up increasingly open-inquiry science learning process for students. Recently, the meaning of open inquiry is quite not clear yet and inquiry practitioners are still discussing about its characterizations. Buck, Bretz and Towns (2008) described the term of "open inquiry" in a way that can be used by both secondary school practitioners and university researchers as an investigation where instructor provides the inquiry question or problem and basic background, but the remaining characteristics are left open to the student, in where learners have to develop their own procedure, analysis, communication, and conclusions to address an instructor provided question. In addition, Srisawasdi (2012b) adapted specifically the idea of open inquiry into context of laboratory work with computer-based learning environment for science classroom. The

matrix of open-inquiry science process for students' learning in computer-based laboratory environment presents in Figure 1.

		Computer-based inquiry activity		
		Pre-lab	Laboratory	Post-lab
Open-inquiry components	Teacher	Open-ended Problem/Question		
		Basic Background/Theory		
	Student		Procedure/Design	
			Result analysis	
				Result communication
				Conclusion

Figure 1. A matrix of open-inquiry science learning with computer-based laboratory environment (Srisawasdi, 2012b)

3. Methods

3.1 Study Participants

The participants for this study included 123 of 11th grade students in three groups: 49 science-major students; 37 technology-focused non-science students; and 37 language-focused non-science students. They attended a physics course for basic education level and were signed up voluntarily to participate in this study. All of them did have satisfactory basic ICT skills they had not any experience with using ICT for science learning before.

3.2 The Integrated Computer-based Laboratory Environment

The integrated computer-based laboratory environment is a type of science learning environment which uses two learning sources such as actual and virtual science laboratories to drive student learning in science and features by effectively incorporating computer-simulated science experiment as virtual source into hands-on science experiment as actual source. In this study, the computer-simulated science experiment and hands-on science experiment was sequentially exposed to student in a supportive manner in turn for their learning as display in Figure 2.

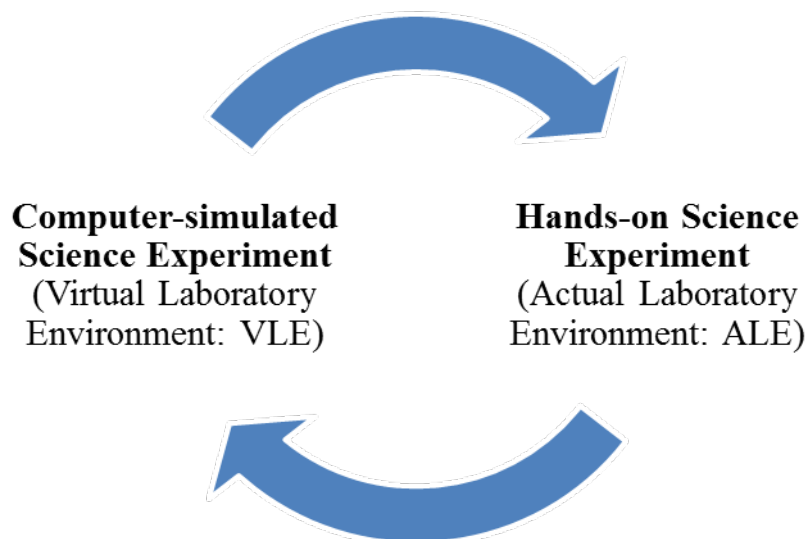


Figure 2. A representation of the in turn nature for integrated computer-based laboratory environment

3.3 Domain of Experimental Learning Events

The integrated computer-based laboratory learning experience, of contact angle measurement, consisted of three sessions including cohesive and adhesive force, hydrophilic and hydrophobic surface, and water contact angle phenomenon, as display in Table 1.

Table 1: Details of the integrated computer-based laboratory activities about surface wettability

Lab	Concept	Description	Scientific Phenomenon
Lab Activity 1	Cohesive and adhesive force; hydrogen bonds	This lab design to provide independent inquiry opportunity in order to discover factors which related to the happening of capillary action phenomenon.	Capillary action
Lab Activity 2	Hydrogen bonds; hydrophilicity and hydrophobicity	This lab design to provide independent inquiry opportunity in order to discover factors which related to the happening of surface wetting situations.	Hydrophilic/ Hydrophobic substances
Lab Activity 3	Cohesive and adhesive force; hydrophilicity and hydrophobicity; hydrogen bonds	This lab design to provide independent inquiry opportunity in order to discover factors which related to the happening of surface wetting and dewetting situation.	Contact angle phenomenon

3.4 Data Collection

For investigating the students' science motivation on their experimental learning experience of integrated computer-based laboratory environment in this study, the students were asked to respond to a 25-item survey instrument of Science Motivation Questionnaire II (Glynn et al., 2011) at both before and after participating the environment. The instrument was a Likert-type scale containing items that present five motivation components: Intrinsic Motivation (IM), Career Motivation (CM), Self-determination (SD), Self-efficacy (SE), and Grade Motivation (GM). Students respond to each item on a five-point-scale of temporal frequency ranging from "never" (0 point) to "always" (4 points). Table 2 presents example statements of item on the survey instrument.

Table 2: Scale description and sample item of the Science Motivation survey instrument

Scale construct	Construct explanation	Example of a construct item
IM	Which involves learning science for its own sakes	Learning science is interesting.
CM	Which involves learning science as a means to an end	Understanding science will benefit me in my career.
SD	Which refers to the control students believe they have over their learning of science	I put enough effort into learning science.
SE	Which refers to students' confidence that they can achieve well in science	I believe I can master science knowledge.
GM	Which refers to the debilitating tension some students experience in association with grading in science	I like to do better than other students on science tests.

3.5 Data Analysis

For analysis of the students' science motivation, their responses to the 25-item survey instrument were scored and the scores was analyzed and described quantitatively. The arithmetic mean and standard deviation were used to score their responses. The means were inferentially compared using independent samples t-tests.

4. Results

Table 3 shows the mean and standard deviation of each constructs of the science motivation including Intrinsic Motivation (IM), Career Motivation (CM), Self-determination (SD), Self-efficacy (SE), and Grade Motivation (GM) on conventional laboratory environment and integrated computer-based laboratory environment and also their comparisons. The statistical analyses of the data reveal that there are statistically significant differences on all constructs (IM, CM, SD, SE, GM) of science motivation for the student in science major. For the student in nonscience major emphasizing technology, there are statistically insignificant differences on GM only. The result also shows statistically significant differences on SD and SE for students in nonscience major emphasizing language, except IM, CM, and GM.

Table 3: Statistical descriptions and results of comparison of science motivation constructs between integrated computer-based laboratory environment and conventional laboratory environment for three groups of student

Motivation Construct	Science Major			Nonscience Major (Emphasizing technology)			Nonscience Major (Emphasizing language)		
	Conven-tional	Integrated	p-value	Conven-tional	Integrated	p-value	Conven-tional	Integrated	p-value
Intrinsic Motivation (IM)									
M	13.37	16.07	.000*	13.43	15.29	.010*	14.13	14.79	.367
SD	3.48	2.43		3.24	2.72		3.07	2.97	
Career Motivation (CM)									
M	14.00	16.07	.001*	13.00	14.43	.043*	12.26	13.50	.120
SD	3.46	2.43		3.15	2.71		4.10	2.67	
Self-determination (SD)									
M	11.89	14.39	.000*	11.89	14.75	.000*	11.09	13.86	.002*
SD	2.91	2.92		3.57	2.71		4.46	3.09	

Motivation Construct	Science Major			Nonscience Major (Emphasizing technology)			Nonscience Major (Emphasizing language)		
	Conven- tional	Integrated	<i>p</i> -value	Conven- tional	Integrated	<i>p</i> -value	Conven- tional	Integrated	<i>p</i> -value
Self-efficacy (SE)									
M	10.63	14.13	.000*	11.48	13.50	.029*	11.09	13.86	.002*
SD	3.47	3.53		4.09	3.58		4.46	3.09	
Grade Motivation (GM)									
M	14.37	16.48	.003*	14.78	16.00	.087	12.80	14.32	.076
SD	3.69	2.94		3.62	2.40		3.87	3.28	

* p value< 0.05

In a summary for Table 3, the integrated computer-based laboratory environment could positively promote better science major students' science motivation than conventional laboratory environment. Especially, the positive on self-determination and self-efficacy of science motivation is also achieved for both nonscience major students. In an addition, the nonscience major student emphasizing technology is positively promoted in intrinsic and career motivations by the integrated computer-based laboratory environment. Nevertheless, the integrated computer-based laboratory environment could not motivate both of nonscience major students in science grade expectation.

In order to compare science motivation on each construct among different groups of student after interacting with the integrated computer-based laboratory environment, Table 4 show the results of comparison.

Table 4: Statistical descriptions and results of comparison of science motivation construct between science and nonscience major students

Motivation Construct	Group	Statistical Comparison		
		ANOVA		Pair-wise comparison
		Mean(SD)	p-value	
IM	Science Major (N=49)	a=16.40(2.51)	.125	a>b a>c b>c
	Nonscience Major (Emphasizing technology) (N=37)	b=15.46(2.62)		
	Nonscience Major (Emphasizing language) (N=37)	c=15.27(2.96)		
CM	Science Major (N=49)	a=16.07(2.43)	.004*	a>b* a>c* b>c
	Nonscience Major (Emphasizing technology) (N=37)	b=14.46(3.11)		
	Nonscience Major (Emphasizing language) (N=37)	c=14.14(2.91)		
SD	Science Major (N=49)	a=14.39(2.92)	.905	a<b a>c b>c
	Nonscience Major (Emphasizing technology) (N=37)	b=14.54(2.83)		
	Nonscience Major (Emphasizing language) (N=37)	c=14.24(2.81)		
SE	Science Major (N=49)	a=14.13(3.51)	.863	a>b a<c b<c
	Nonscience Major (Emphasizing technology) (N=37)	b=13.81(3.56)		
	Nonscience Major (Emphasizing language) (N=37)	c=14.27(3.03)		
GM	Science Major (N=49)	a=16.48(2.94)	.023*	a>b a>c* b>c
	Nonscience Major (Emphasizing technology) (N=37)	b=16.16(2.68)		
	Nonscience Major (Emphasizing language) (N=37)	c=14.73(3.21)		

In a summary for the Table 4, the integrated computer-based laboratory environment has impact indifferently on IM, SD, and SE for all student groups. This means the laboratory environment could involve their learning science for its own sakes. Moreover, it made believe and confidence in their

own performance over their learning of science in the same for all groups. However, the impact of the environment on CM and GM was different for the student groups. The result indicated that the perceiving of career motivation for science and non-science major students was significantly different, and the perceiving of grade motivation, particularly, for science and non-science major emphasizing language was also significantly different. This means that the laboratory environment provided the involvement of learning science as a means to an end and the debilitating tension which students experience in association with grading in science for science major student greater than non-science major students.

5. Conclusion

This paper reported on the use of integrated computer-based laboratory environment to promote student's science motivation by comparing of science and non-science major student in the context of Grade 11 secondary school student. On the comparing of between conventional laboratory environment and integrated computer-based laboratory environment, all groups of student (both science and non-science major student) were getting promotion on their own self-determination and self-efficacy. Particularly, the science major students were completely getting promotion on their motivation towards science learning by the use of integrated computer-based laboratory environment. This implied that the laboratory environment could be used effectively to transform science motivation for science major and non-science major emphasizing technology students. For non-science major emphasizing language students, they were motivated on their own believe and confidence that they can perform and achieve well in science only. This implied that the laboratory environment supported credibility of learning in science. In an effort to better serve changing science learning environment into more motivated learning environment especially for both science and non-science major student, the finding illustrates that integrated computer-based laboratory environment could be particularly considered as a core attributes for motivating student learning in science. It should be used to help taking them into loving in learning of science.

Acknowledgement

This work was financially supported by the cooperation of the Thailand Research Fund (TRF), the Commission on Higher Education (CHE), and Khon Kaen University (KKU), grant No. MRG5480058.

References

- Buck, L. B., Bretz, S. L., & Towns, M. H. (2008). Characterizing the level of inquiry in the undergraduatelaboratory. *Journal of College Science Teaching*, 38(1), 52–58.
- Gilbert, J. K. (2006). On the nature of 'context' in chemical education. *International Journal of Science Education*, 28(9), 957–976.
- Glynn, S. M., Brickman, P., Armstrong, N., & Taasobshirazi, G. (2011). Science Motivation Questionnaire II: Validation with science majors and nonscience majors. *Journal of Research in Science Teaching*, 48, 1159-1176.
- Kim, M. C., Hannafin, M. J., & Bryan, L. A. (2007). Technology-enhanced inquiry tools in science education: *An emerging pedagogical framework for classroom practice*. *Science Education*, 91(6), 1010-1030.
- Krajcik, J. S. & Blumenfeld, P. (2006). Project-based learning. In Sawyer, R. K. (Ed.), *the Cambridge handbook of the learning sciences*. New York: Cambridge.
- Kuhn, D., Black, J. B., Kesselman, A., & Kaplan, D. (2000) The development of cognitive skills to support inquiry learning. *Cognition and Instruction*. 18, 495-523.
- Linn, M. C. (1998). The impact of technology on science instruction: Historical trends and current opportunities. In M. C. Linn (Eds.) *International handbook of science education*, Netherlands: Kluwer Publishers.
- Novak, A. & Krajcik, J. S. (2005). *Using Learning Technologies to Support Inquiry in Middle School Science*. In Flick, L. & Lederman, N. (Eds) *Scientific Inquiry and Nature of Science: Implications for Teaching, Learning, and Teacher Education*. Netherlands: Kluwer Publishers.

- Songer, N. B. (1998). Can technology bring students closer to science? In B. J. Fraser & K. G. Tobin, *International Handbook of Science Education* (pp. 333-347). Netherlands: Kluwer.
- Srisawasdi, N. & Suits, J. P. (2012). Effect of learning by simulation-based inquiry on students' mental model construction. Proceedings of the 20th International Conference on Computers in Education. Singapore: Asia-Pacific Society for Computers in Education
- Srisawasdi, N. (2012a). Introducing Students to Authentic Inquiry Investigation by Using an Artificial Olfactory System. In K. C. D. Tan, M. Kim, & S. W. Hwang (Eds.) *Issues and challenges in science education research: Moving forward* (pp. 93-106). Dordrecht, Netherlands: Springer.
- Srisawasdi, N. (2012b). Student teachers' perceptions of computerized laboratory practice for science teaching: a comparative analysis. *Procedia – Social and Behavioral Sciences*, 46, 4031-4038.
- Srisawasdi, N. (2012c). The role of TPACK in physics classroom: case studies of pre-service physics teachers. *Procedia – Social and Behavioral Sciences*, 46, 3235-3243.
- Srisawasdi, N., Kerdcharoen, T., & Suits, J. P. (2008). "Turning scientific laboratory research into innovative instructional material for science education: Case studies from practical experience". *The International Journal of Learning*, 15(5), 201-210.
- Thomas, G. P. (2001). Toward effective computer use in high school science education: where to form here? *Education and Information Technologies*, 6(1), 29-41.
- Tinker, R. & Papert, S. (1989) Tools for Science Education, in J. Ellis (Eds.) *Information Technology & Science Education*. Columbus: OH, AETS.
- Waight, N. & Abd-El-Khalick, F. (2007). The impact of technology on the enactment of "inquiry" in a technology enthusiast's sixth grade science classroom. *Journal of Research in Science Teaching*, 44(1), 154-182.
- Zoller U. (2000), Teaching tomorrow's college science courses – are we getting it right? *Journal of College Science Teaching*, 29, 409-414.

Guideline for the Development of Personalized Technology-enhanced Learning in Science, Technology, and Mathematics Education

Patcharin PANJABUREE^a & Niwat SRISAWASDI^{b*}

^a*Institute for Innovative Learning, Mahidol University, Thailand*

^b*Faculty of Education, Khon Kaen University, Thailand*

*niwsri@kku.ac.th

Abstract: With a rapidly changing world, science, technology, and mathematics (STM) hold the key to achieve a certain level of development. Technology in education is, therefore, a key ingredient to enhance learning as it helps produce creative and lifelong learning individual students. Recent progress in computer and communication technology has encouraged the researchers to demonstrate the pivotal influences of technological personalized learning environments on student learning performance improvement. Many researchers have been investigating the development of such learning environment by basing upon the concept-effect relationship model on student learning performance improvement. Such learning environment has been demonstrated to be useful for helping teachers to diagnose learning problems for individual students according to test answers, and to provide personalized remedial learning guidance for improving students' learning performance. However, each student has different preferences and needs, which are very important factors, affecting on STM learning ability. Moreover, individualizing the learning experience for each student is an important goal for educational systems. It is very crucial to provide the different styles of learners with different learning environments that are more preferred and more efficient to them. Therefore, this paper proposes a guideline for the development of personalized technology-enhanced learning where the student's conceptual learning problems and preferences are diagnosed, and then user interfaces are customized in an adaptive manner to accommodate such learning problems and preferences, in order to emphasize on promoting STM education.

Keywords: STM education, e-learning, adaptive learning, technology-enhanced learning, concept-effect relationship model

1. Introduction

In STM education community, most educators are concerned about applying teaching and learning theories/strategies/approaches to enhance students learning ability. For example, inquiry-based learning approach, which is promised to improve STM teaching by engaging students in authentic investigations emphasizing on posing questions, gathering and analyzing data, and constructing evidence-based arguments, has been applied to achieving a more realistic conception of scientific endeavor as well as providing a more student-centered and motivating environment (Kuhn, Black, Keselman, & Kaplan, 2000; Kubicek, 2005; Krajcik & Blumenfeld, 2006). A learning cycle approach basing on the concept of inquiry-based learning approach is most widely used in promoting the students' understanding in the idea of chemistry education, biological education, physics education, life science course, and computer science education (Allard & Barman, 1994; Ates, 2005; Dibley & Parish, 2007; Kaynar, Tekkaya, & Cakiroglu, 2009; Liu, Peng, Wu, & Lin, 2009). This approach could enable an opportunity for students to reveal their prior knowledge exist in two ways such as they make predictions before exploring, and generate hypotheses to explain new phenomena. From these studies, the researchers reported that students still often displayed learning difficulties in understanding and hold failures status of conceptual understanding for real world phenomena. Although learning activities based on the effective teaching and learning approach, in reality, each student has different preferences and needs. These mentions are

very important factors affecting on STM learning ability and individualizing the learning experience for each student is an important goal for educational systems (Snow & Farr, 1987; Russell, 1997). Therefore thinking about learner difference and personalized learning information and providing the different styles of learners with different learning environments during applying teaching and learning theories/strategies/approaches in STM are more preferred and more efficient to them, it might overcome learning difficulties in understanding and hold failures status of conceptual understanding for real world phenomena.

In past decade, the rapid advance of computers and communication technologies has promoted the utilization of technological applications in STM educations. The technology in STM education serves as a key ingredient to enhance learning as it helps produce creative and lifelong learning for individual students and promotes personalized learning as well. However, managing STM classroom with a large number of students is very difficult when concerning about the learner difference and personalized learning information. Personalized or adaptive online-based learning, thus, has been becoming to overcome that issue in technology-enhanced learning and teaching (Smith & Smith, 2004; Sun, Lin, & Yu, 2008; Yang, & Tsai, 2008; Akbulut & Cardak, 2012; Chookaew, Panjaburee, Wanichsan, & Laosinchai, 2013). To realize personalized technology-enhanced learning, STM-concept status and learning style are two of the key components. The personalized technology-enhanced learning environment is referred to enable individual students to improve their own learning performance (Chen, 2008; Chen, 2011). Consequently, many researchers have developed personalized technology-enhanced learning environment based on several approaches, models, and algorithms including Bayesian cybernetics, fuzzy rules, genetic algorithms, clustering techniques and concept-effect relationship model (Bai & Chen, 2008a; Cheng, Lin, Chen, & Heh, 2005; Kaburlasos, Marinagi, & Tsoukalas, 2008; Panjaburee, Hwang, Triampo, & Shih, 2010).

In the recent years, several researchers have applied concept-effect relationship model to develop technological personalized learning environment (Bai & Chen, 2008a, 2008b; Chen, 2008; Chen & Bai, 2009; Chu, Hwang, Tseng, & Hwang, 2006; Günel & Aşlıyan, 2010; Hwang, 2003; Hwang, Panjaburee, Shih, & Triampo, 2013; Panjaburee et al., 2010). Successful uses of this model not only demonstrated the benefits of applying it for coping with learning diagnosis problems but also enhanced learning performance in several areas including natural science, mathematics, and health education. In this paper, therefore, we propose a guideline for the development of personalized technology-enhanced learning. This guideline will take into account two aspects about the conceptual status, which presents the learning status of each concept of each student in the course content, needs to be diagnosed by the testing and diagnosing process within a personalized technology-enhanced learning system. Moreover, learning style of each student is needed to be identified for adapting user interfaces within a personalized technology-enhanced learning system, in order to emphasize on promoting STM education.

2. Characteristics of Concept-Effect Relationship Model

In 2003, Hwang firstly proposed the concept of concept-effect relationship (CER) as a concept-map oriented approach as the researchers/ practitioners/ teachers/ experts need to define the prerequisite relationships among concepts to be learned in hierarchical order based on curriculum or teaching experience before the course begin (Hwang, 2003). The CER is appropriated for the subject containing the explicit concept relationships. Panjaburee et al. in 2010 showed an example of CER construction on topic “Division of Positive Number” is shown in Figure 1.

In Figure 1., consider two concepts, C_i and C_j , concept “C2 Addition of Positive Integer” is a prerequisite for the efficient performance of the more complex and higher-level concepts “C3 Subtraction of Positive Integer” and “C4 Multiple of Positive Integer”. Clearly, a concept may have multiple prerequisite concepts, and a given concept can also be a prerequisite concept of multiple concepts. Therefore, if a student fails in C_5 , it may be caused of incompletely learn in C_3 and C_4 .

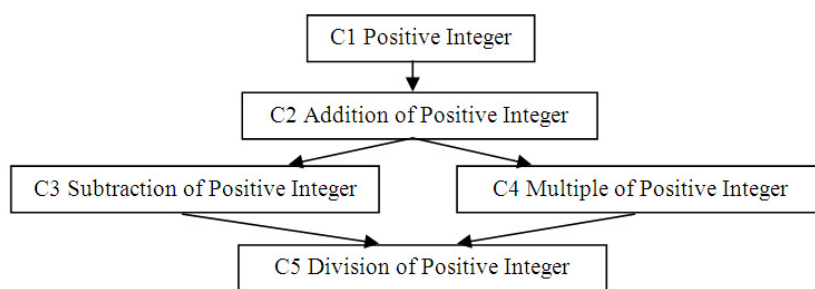


Figure 1. Illustrate example of CER construction on topic “Division of Positive Number”

Following the construction of CER the main problem is how to diagnose student conceptual learning problems. Obviously, previous research used the CER to diagnose student conceptual learning problems in five steps (Hwang, 2003; Hwang et al., 2008): (1) Constructing the CER for the subject unit. (2) Presetting the weight values between test item and related concepts. (3) Calculating the incorrect answer rate for each student in each concept. (4) Defining a concept which affects the learning of other related concepts. (5) Providing feedback and corresponding learning material to each student. These five steps of the use of CER are called the CER model in diagnosing student conceptual learning problem in technological personalized learning environment.

3. A conceptual framework for adaptive learning with conceptual status

As a learner learning difficulties, conceptual status is an indicator of how well a learner learns and needs to be improved. If educators want to successfully address the needs of the individual they must understand how well a learner learns and adjust the difficulty level of subject material to meet the conceptual status of each learner. Within an adaptive learning system, the testing and diagnostic process widely used to diagnose conceptual status of each learner. To acquire the personalized information about conceptual status of each concept in the course content, usually, several researchers in the area of technology-enhanced learning and teaching have applied the concept of a Fuzzy membership function (Hwang, 2003; Chu, Hwang, Tseng, & Hwang, 2006; Bai & Chen, 2008; Panjaburee, Hwang, Triampo, Shih, 2010; Srisawasdi, Srikasee, & Panjaburee, 2012; Panjaburee, Triampo, Hwang, Chuedoung, & Triampo, 2013). Before starting this testing and diagnosing process, the teachers need to develop the test items which cover all concepts that student need to learn in the course content and determine the intensity of association concepts for each test item. Normally, the intensity values range from 0 to 5, with 0 indicating no relationship and 1-5 representing the intensity of the relationship, with 5 the most intense (as shown in Table 1).

Table 1. Illustrative example of intensity values between concept and test item (adapt from Srisawasdi, Srikasee, & Panjaburee, 2012)

Concepts Test Items	1	2	3	4	5	6	7	8	9
1	2	0	5	0	0	0	0	0	0
2	1	0	5	0	0	1	0	0	0
3	4	4	5	1	1	0	0	0	0
4	4	4	5	2	1	1	0	0	0
5	2	5	5	1	4	1	0	0	0
6	1	5	3	5	5	0	5	0	0
7	0	0	1	0	0	0	0	5	0

Concepts Test Items	1	2	3	4	5	6	7	8	9
8	5	3	2	5	1	2	0	0	0
9	0	1	0	0	0	0	0	0	5
10	5	0	0	0	0	0	0	0	5
Sum	24	22	31	14	12	5	5	5	10
Error	9	8	16	3	2	2	0	5	0
Error Rate	0.38	0.36	0.52	0.21	0.17	0.80	0.00	1.00	0.00

The summary steps in the testing and diagnosing process for diagnosing learners' conceptual status consist of the following steps:

Step1: Finding concepts related to the test items that a learner failed to correctly answer, assuming that the learner failed to correctly answer of test item 2, 3, 4, and 7.

Step2: Calculating the error of each concept by summation of the intensity only failed test item 2, 3, 4, and 7.

Step3: Calculating error rate of each concept by division of error by sum. As indicated in Table 1, the error rate of concept 1 is $9/24 = 0.38$, indicating that the learner failed to answer 38% of the test items related to concept 1.

Step4: Finding the conceptual status of the student by applying the Fuzzy membership function as shown in Figure 2. For example, error rate of concept 6 is 0.80. 0.80 in x-axis will meet the maximum value at HIGH curve in y-axis. It means that the student has high error in this concept, implying that the conceptual status of this concept is poorly-learned. Otherwise, if the student has low error in this concept, implying that the conceptual status of this concept is well-learned. If the student has medium error in this concept, implying that the conceptual status of this concept is partial-learned.

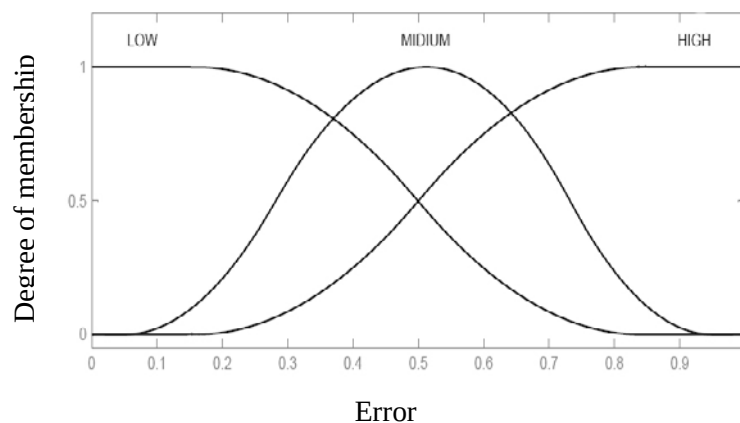


Figure 2. Illustrate Fuzzy membership function

For the benefit of the Fuzzy membership function in judging the conceptual status of each concept for each learner, we can easily gain the personalized conceptual status within an online-based learning system. Based on this information, the content on online-based learning system could be adapted to fit with each learner in specific conceptual status (well-, partial-, or poorly-learned).

4. Examples of CER model-based implementation

Regarding it is necessary to establish the degree of association between test item and related concepts in the CER model, Panjaburee et al., in 2010, proposed a multi-expert approach to integrate such degree

given by multiple experts/ domain to making high quality degree of association between test item and related concepts. The integrated degree was used to be input in a testing and diagnostic learning problem (TDLP) system which was developed basing upon the concept of CER model. Panjaburee et al. (2010) evaluated the effectiveness of their system on mathematics course for topic “System of Linear Equation” with 113 secondary school students in Thailand. Three teachers with fifteen experienced teaching on the topic were domain experts in this study. The participating students, thus, were divided into 4 groups (i.e., three control groups and one experimental group). Students in control groups were asked to participate in TDLP linked with the degree of association between test item and related concepts given by single expert, while those in experimental group were asked to involve in TDLP linked with the degree of association between test item and related concepts given by multiple experts. All students were asked to log on the online system to take a pre-test. The system analyzed their answers, provided the learning performance level of each concept related to the topic, guided the way to improve their own learning problems, and gave supplementary homework in paper-based format accordingly. We could see that the students in control group 1, 2, and 3 received those personalized information given by domain expert 1, 2, and 3, respectively, and those in experimental group received the information from integrated opinion of these three domain experts. After experiencing corresponding homework, all students took a post-test to compare learning achievement among four groups. This study showed that students in experimental group performed significant better than those in control groups. Finally, Panjaburee et al. mentioned that a multi-expert approach could help students improved learning achievement after experiencing in a TDLP based on the CER model.

Similarly, regarding CER serves as a tool for tracing conceptual learning problems, Hwang et al., in 2013, proposed a group decision approach to integrate CER from multiple experts/ domain to making high quality CER. The integrated CER was used to be input in a testing and diagnostic system which was developed basing upon the concept of CER model. Hwang et al. (2013) evaluated the effectiveness of their system on mathematics course for topic “Computations and Applications of Quadratic Equations” with 104 secondary school students in Taiwan. Three teachers with four experienced teaching on the topic were domain experts in this study. The participating students, thus, were divided into 4 groups (i.e., three control groups and one experimental group). Students in control groups were asked to participate in a testing and diagnostic system linked with the CER given by single expert, while those in experimental group were asked to involve in a testing and diagnostic system linked with the CER given by multiple experts. After taking a pre-test, the students in three control groups received learning suggestions based on the CER given by domain expert 1, 2, and 3, respectively, while those in experimental group received learning guidance followed by the CER from integrated opinion of three experts. The system then provided supplementary material related with personalized conceptual learning suggestions. After finishing learning activities, all students took a post-test. The post-test results showed that there was significant different score between the low-achieved students in experimental group and those in three control groups. Hwang et al. concluded that a group decision of multiple experts could help students improved learning achievement after experiencing in a personalized learning material based on the CER model.

However, it is not enough to address the learner differences issue with only one aspect. Because each learner might have his/her learning style, therefore, another aspect, learning style, is needed to be identified for adapting user interfaces within a personalized technology-enhanced learning system.

5. A conceptual framework for adaptive learning with learning style

Over the past decade, several researchers have defined learning style and addressed the concept of learning styles and the various ways they are measured (Keefe, 1979; Cavaiani, 1989). Learning style refers to the different ways that each learner uses to perceive, process, and conceptualize information. As a learner characteristic, learning style is an indicator of how a learner learns and likes to learn. Moreover, if educators want to successfully address the needs of the individual they must aware how learner likes to learn and adjust their teaching styles to meet the learning styles of each student. As we know identifying and accommodating diverse learning styles is a hard task in any classroom environment (Gilbert & Han, 1999). In the recent years, several researchers in the area of technology-enhanced learning and teaching have developed online-based learning system by

concerning about the learning style (Smith & Smith, 2004; Sun, Lin, & Yu, 2008; Tseng, Chu, Hwang, & Tsai, 2008; Yang, & Tsai, 2008; Zacharis, 2011; Akbulut & Cardak, 2012; Chookaew, , Panjaburee , Wanichsan, & Laosinchai, 2013). The system could help educators identify and adjust learning environment by accommodating diverse learning styles. And also the learners could improve learning ability because they participate in learning environment that they prefer.

In personalized technology-enhanced learning environment, there are various information sources and various ways of presenting learning content. Felder & Soloman's (1988) Index of Learning Style (ILS) questionnaire might be the most suitable model for an adaptive personalized technology-enhanced learning system. Especially, the visual/verbal dimension plays an important role in determining how a learner receives and processes information. If the students are visual student, the personalized technology-enhanced learning system assumes that they could remember best by seeing. Thus, the system will present the learning material as pictures, animations, and demonstrations for them. For those who are verbal ability, the system assumes that they could gain understanding of material by hearing; therefore, the system will generate the learning material as text, spoken explanations, and exercises to be completed with their friends.

6. Guideline for the Development of Personalized Technology-enhanced Learning in Science, Technology, and Mathematics Education

Due to attention to the personal learning needs of individual students, the educational system can be successful (Russell, 1997). Moreover, educators should use the technology to serve students differences. As the conceptual frameworks above, when developing personalized technology-enhanced learning system, we could not pay attention to single personalized information of student such as conceptual status (including well-, partial-, or poorly-learned) or learning style, while the integration of two sources of personalized information are ignored. If we develop personalized technology-enhanced learning system based only on conceptual status, the students might not participate in learning environment that they prefer. Otherwise, if we develop personalized technology-enhanced learning system based only on learning style, the students could not learn in subject material with difficulty level does not fit with their own performance level. So, it could not use the maximum proficiency of technology to serve students differences. If we can integration those two sources of personalized information for personalized technology-enhanced learning system, it would be benefit for teachers and students in order to promote thinking and could become innovative part of existing model of inquiry-based STM learning by the way of using computer-based instructional technologies. Because, without face-to-face communication in any classroom, teachers could gain student personalized information for preparing any subject material to fit with each student. In the same time, students could participate in subject material with difficulty level corresponding with their own conceptual status and also in user interface of personalized technology-enhanced learning adjusted for the way they like to learn.

Therefore, in this paper, we propose a guideline to manage personalized technology-enhanced learning system in order to emphasize on promoting STM education as shown in Figure 3. The students will take the on-line conceptual test. When the teachers examined the intensity value of association concepts for each test item and the student submitted his/her answers of the conceptual test sheet, the testing and diagnosing process in a personalized technology-enhanced learning system can work effectively. The personalized technology-enhanced learning system will diagnose his/her conceptual learning status and provide the conceptual status of each concept to each student. The students then take a learning style questionnaire and the student submitted his/her answers of the questionnaire, the personalized technology-enhanced learning system will analyze their own learning style. The student will participate in subject material corresponding with conceptual status (well-, partial-, or poorly-learned) of each concept with the user interface adjusted basing upon their own learning style within the personalized technology-enhanced learning system.

This is our framework in which we take into account two aspects about the conceptual status, which presents the learning status of each concept of each student in the course content, needs to be diagnosed by the testing and diagnosing process within a personalized technology-enhanced learning

system. Moreover, learning style of each student is needed to be identified for adapting user interfaces within a personalized technology-enhanced learning system.

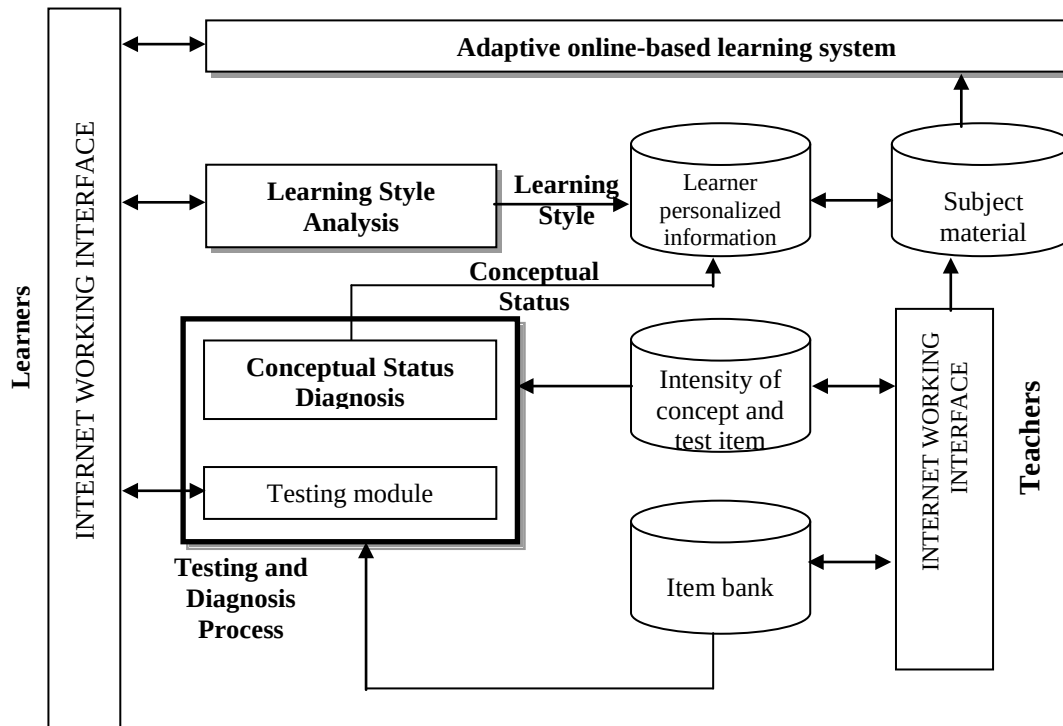


Figure 3. Framework for personalized technology-enhanced learning system

7. Conclusion

To realize personalized technology-enhanced learning system, concept status and learning style are two of the key components. In this paper, a framework for personalized technology-enhanced learning system with integrative diagnosis of conceptual status and learning style is proposed. This framework could be the maximum use of technology to serve learners differences within adaptive online-based learning system. Moreover, it could be served as innovative way of STM education when using computer-based instructional technologies.

References

- Akbulut, Y. & Cardak, S. C. (2012). Adaptive educational hypermedia accommodating learning styles: A content analysis of publications from 2000 to 2011. *Computers & Education*, 58, 835–842.
- Allard, D. W., & Barman, C. R. (1994). The learning cycle as an alternative method for college science teaching. *BioScience*, 44(2), 99-101.
- Ates, S. (2005). The effectiveness of the learning-cycle method on teaching DC circuits to prospective female and male science teachers. *Research in Science & Technological Education*, 23(2), 213-227.
- Bai, S. M., & Chen, S. M. (2008a). Automatically constructing concept maps based on fuzzy rules for adapting learning systems *Expert Systems with Applications*, 35, 41–49.
- Bai, S. M., & Chen, S. M. (2008b). Evaluating students' learning achievement using fuzzy membership functions and fuzzy rules *Expert Systems with Applications*, 34, 399–410.
- Cavaiani, T. P. (1989). Cognitive style and diagnostic skills of student programmers. *Journal of Research on Computing in Education*, 21(4),411–420.
- Chen, C. M. (2008). Intelligent web-based learning system with personalized learning path guidance. *Computers & Education*, 51, 787–814.
- Chen, L. H. (2011). Enhancement of student learning performance using personalized diagnostic and remedial learning system. *Computers & Education*, 56, 289–299.
- Chen, S. M., & Bai, S. M. (2009). Learning barriers diagnosis based on fuzzy rules for adaptive learning systems *Expert Systems with Applications*, 36, 11211–11220.

- Cheng, S. Y., Lin, C. S., Chen, H. H., & Heh, J. S. (2005). Learning and diagnosis of individual and class conceptual perspectives: an intelligent systems approach using clustering techniques. *Computers & Education*, 44, 257–283.
- Chookaew, S., Panjaburee, P., Wanichsan, D., & Laosinchai, P. (2013). A Personalized E-Learning Environment to Promote Students' Conceptual Learning on Basic Computer Programming. *Procedia - Social and Behavioral Sciences* (In Press).
- Chu, H. C., Hwang, G. J., Tseng, J. C. R., & Hwang, G. H. (2006). A computerized approach to diagnosing student learning problems in health education. *Asian Journal of Health and Information Sciences*, 1, 43-60.
- Dibley, J., & Parish, J. (2007). Using video games to understand thermoregulation. *Science Scope*, 30(8), 32-35.
- Felder, R. M., & Solomon, B. A. (1988). Learning and teaching styles in engineering education. *Journal of Engineering Education*, 78(7), 674-681.
- Gilbert, J. E. & Han, C.Y. (1999). Adapting instruction in search of a significant difference. *Journal of Network and Computing Applications*, 22(3), 149–160.
- Günel, K., & Aşlıyan, R. (2010). Extracting learning concepts from educational texts in intelligent tutoring systems automatically. *Expert Systems with Applications*, 37, 5017–5022.
- Hwang, G. J. (2003). A conceptual map model for developing intelligent tutoring systems. *Computers & Education*, 40, 217–235.
- Hwang, G. J., Panjaburee, P., Shih, B. Y., & Triampo, W. (2013). A group decision approach to developing concept effect models for diagnosing student learning problems. *British Journal of Educational Technology*, 44(3), 453-468.
- Hwang, G. J., Tseng, J. C. R., & Hwang, G. H. (2008). Diagnosing student learning problems based on historical assessment records. *Innovations in Education and Teaching International*, 45, 77-89.
- Kaburlasos, V. G., Marinagi, C. C., & Tsoukalas, V. T. (2008). Personalized multi-student improvement based on Bayesian cybernetics. *Computers & Education*, 51, 1430–1449.
- Kaynar, D., Tekkaya, C., & Cakiroğlu, J. (2009). Effectiveness of 5E learning cycle instruction on students' achievement in cell concept and scientific epistemological beliefs. *Hacettepe University Journal of Education*, 37, 96-105.
- Keefe, J. W. (1979). Learning style: An overview. In National association of secondary school principals (Ed.), *Student learning styles: Diagnosing and prescribing programs* (pp. 1-17). Reston, Virginia: National Association of Secondary School Principals.
- Krajcik, J. S., & Blumenfeld, P. C. (2006). Project-based learning. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 317–334). New York: Cambridge.
- Kubicek, J. P. (2005). Inquiry-based learning, the nature of science, and computer technology: New possibilities in science education. *Canadian Journal of Learning and Technology*, 31(1). Retrieved from <http://www.cjlt.ca/index.php/cjlt/article/view/149>
- Kuhn, D., Black, J., Keselman, A., & Kaplan, D. (2000). The development of cognitive skills to support inquiry learning. *Cognition and Instruction*, 18(4), 495–523.
- Liu, T.-C., Peng, H., Wu, W.-H., & Lin, M.-S. (2009). The effects of mobile natural-science learning based on the 5E learning cycle: A case study. *Journal of Educational Technology & Society*, 12(4), 344-358.
- Panjaburee, P., Hwang, G. J., Triampo W., & Shih, B. Y. (2010). A multi-expert approach for developing testing and diagnostic systems based on the concept-effect model *Computers & Education*, 55, 527–540.
- Panjaburee, P., Triampo, W., Hwang, G. J., Chuedoung, M., & Triampo, D. (2013). Development of a diagnostic and remedial learning system based on an enhanced concept effect model. *Innovations in Education and Teaching International*, 50(1), 72-84.
- Russell, T. (1997). Technology wars: Winners and losers. *Educom Review*, 32(2), 44–46.
- Snow, R., & Farr, M. (1987). Cognitive-conative-affective processes in aptitude, learning, and instruction: An introduction. *Conative and affective process analysis*, 3, 1–10.
- Smith, S. E & Smith, J. P. (2004). Strategies for accommodating individuals' styles and preferences in flexible learning programmes. *British Journal of Educational Technology*, 35(4), 395–412 .
- Srisawasdi, N., Srikasee, S., & Panjaburee, P. (2012). Development of a Constructivist Web-based Learning System with Student Personalized Conceptual Profile. *Proceedings of the 20th International Conference on Computers in Education*. Singapore: Asia-Pacific Society for Computers in Education. 44-50
- Sun, T. Y., Lin, C. Y., & Yu, J. C. (2008). A study on learning effect among different learning styles in a Web-based lab of science for elementary school students. *Computers & Education*, 50, 1411–1422.
- Tseng, J. C. R., Chu, H. C., Hwang, G. J., & Tsai, C. C. (2008). Development of an adaptive learning system with two sources of personalization information. *Computers & Education*, 51(2), 776-786.
- Yang, Y. F., & Tsai, C. C. (2008). Investigating university student preferences and beliefs about learning in the web-based context. *Computers & Education*, 50, 1284–1303.
- Zacharis, Z. N. (2011). The effect of learning style on preference for web-based courses and learning outcomes. *British Journal of Educational Technology*, 42(5), 790–800.

Stimulating Self-Regulation for High and Low Achievers in a Self-Directed Learning Environment

Andrew C.-C. LAO^{a*}, Mark C.-L. HUANG^a & Tak-Wai CHAN^a

^aGraduate Institute of Network Learning Technology, National Central University, Taiwan

*ccl.andrew@gmail.com

Abstract: The forthcoming trend of personalized learning drives the further development of individualization. Studies that relate to individual learning show possibilities for personalized learning in current education. This is because the goal of both individual and personalized learning are focused on how to help students pursue their learning and provide assistance to help students become lifelong learners. From the basis of cognitive theories, we believe that elementary students are able to be responsible for their own learning. However, most studies that related to individual learning were mainly from adult and adolescent education. In addition, as stated in Self-Determination Theory (Deci & Ryan, 1985), Deci & Ryan believed that self-regulation showed possible relation to student's motivation in learning. Hence, students' motivation plays an essential role in both individual learning and personalized learning. There needs to explore the factor that affects students' motivation. In order to help elementary students learn autonomously, there needs to explore the factors that affect student's motivation in learning. As a result, this study applied Self-Directed Learning (SDL) into math classrooms for exploring differences between high and low achievers in the motivation for learning. In this study, high achievers were more beneficial than the low achievers, where high achievers showed a significant difference with the low achievers on self-efficacy for learning & performance, metacognitive self-regulation, intrinsic goal orientation and resource management strategies: time and study environment.

Keywords: motivation, self-directed learning, self-regulation

1. Introduction

Hargreaves (2004) purposed nine gateways for personalized learning. The nine gateways stand for student voice, assessment for learning, learning to learn, new technologies, curriculum, advice & guidance, mentoring & coaching, workforce reform and design & organization. One of the nine gateways -- student voice was described as a key element for personalization in education. It defines student's perception in education and it also implies that education should be tailored into specific needs, which depend on student's personality, learning strategies, or problem solving skills. On the other hand, from the development of adaptive learning to personalized learning, student is able to actively choose their favorite learning materials and determine their own pace based on their learning portfolios, rather than passively receiving assignment from teachers. To this end, interest is crucial because it affects the choice that students would make, the pace that students would pursuit, and the strategy that student would adopt. As students grew up, studies pointed out that students' interest would become lower when they reached a higher grade in school, because the difficulty and complexity of formulated assessments increases with the growth of grades (Boggiano, Barrett, Weiher, McClelland, & Lusk, 1987; Covington & Omelich, 1985). Moreover, in order to stimulate student's interest in learning, there needed to explore essential elements that affected students' learning interest. Therefore, as stated in Self-Determination Theory, the intrinsic motivation and extrinsic motivation particularly related to the interest of students' learning (Deci & Ryan, 1985). It implied that both the intrinsic and extrinsic motivation played a certain role for student's interest in learning. Most students who lacked learning interests or motivation would show a deep depression or declines to learn, and some students even failed to understand the lectures in school.

As a result, in order to enhance student's motivation in learning, Tough (1979) and Knowles (1975) purposed Self-Directed Learning (SDL) for enhancing student's individuality in adult education. SDL provides a guidance that helps students prepare for their learning goals, reflect on their learning experiences, and learn with or without the assistance of classroom teachers. Also, SDL was believed as a possible solution to the personalization in learning, because students were being responsible for their learning decisions (Knowles, Holton & Swanson, 2011). In a SDL environment, students set their own goals, determine their own pace, negotiate proposals with the teacher, and revise the work that they learned (Gibbons, 2002). Gibbons showed elements that formulated the transformation of classroom learning which includes alternative choices for the design of SDL classrooms (such as guidelines for teachers, students and lesson plans). He also provided a framework for SDL in adolescent education, which students learned in a self-planned environment, and students learned under the guidance or assistance by the teacher in the SDL classroom. However, SDL was seldom discussed in elementary level in regular classrooms until recently a study by Tan, Shanti, Lynde, Cheah (2011) discussed the application at the elementary level. Tan et al. describes the experience on elementary student's characteristics, including the ownership, monitoring and management. Tan et al. believed that teacher's perception and assistance played an essential role in SDL, so they adopted the concept in adult education but they focused more on the elementary student's ownership, monitoring, teacher's professional training and assessment for SDL. We believed that students, especially in the elementary level, could be responsible for their learning. This is crucial for personalized learning because it would be able to help students become lifelong learners. Therefore, the ways that cultivating student's autonomous engagement should be taken into consideration.

Therefore, this study designs a framework that intends to explore the motivation for learning in regular classrooms and provide a preliminary analysis for the differences between high and low achievement students. In addition, this framework provides integrations among regular curriculum, goal settings, and monitoring. In this study, students will be able to strive for their own pace, which implied a personalized pace for individual students. In pursuing student's personalization, students determined their own pace based on their math learning capability, and they had to decide whether to accept additional challenges or other learning activities.

2. Literature Review

2.1 Motivation and Self-Regulation for Learning

Renninger & Hidi (2002) stated that interest includes affective and cognitive components, which are parts of individuals' engagement in learning activities. Also, motivation is considered as a means to the willingness of finishing certain learning activity (diSessa, 2000), and the self-regulation for personal management in the learning task. Self-regulation would be an essential element for the outcome of students' personalized learning. Studies explored the effects on the relation between self-regulation and the learning achievement, in which students were associated with the learning efficacy for learning autonomously in either in-class or after-class environment (Dweck, 1986; Wolters, Yu, & Pintrich, 1996). In the study by Cleary & Chen (2009), they believed that students with high self-regulation would deliver a greater strategies used than the low self-regulation students. Students with high self-regulation referred to higher goal settings, learning plans and strategies. With the high ability of goal setting, students were more able to pursuit the goal, which based on their own learning capabilities. The higher learning skills on plans and strategies, which implied the more appropriate choice on plans and strategies, the higher effective goals would be applied during the learning activity. In addition, different goals stand for different factors for motivation. It referred to the enjoyment on doing something that related to either intrinsic or extrinsic motivation in learning (Deci & Ryan, 1985; Ryan & Deci, 2000).

2.2 Self-Directed Learning (SDL) and Its Application

In SDL, students have to set their goals and negotiate the learning agreement or contract with the classroom teacher. Knowles (1975) defines SDL with 5 elements (diagnosing student's learning needs,

formulating student's learning goals, identifying human and non-human resources, selecting and applying learning strategies, and evaluating learning outcomes). These elements forms SDL as helping students for fulfilling the needs of learning goals, which consist of plans or contracts among instructors, students and peers. In Knowles' another work (Knowles, 1986), he suggested that the learning contracts should consist of:

- The acquisition for knowledge, skill, attitude, and value: this described the forthcoming acquisition by the students. In a math classroom of a public school, it referred to the domain knowledge such as conceptual understanding (math concepts, operations), procedural fluency (accuracy, effectiveness), strategic competence (problem solving) ... etc. (Kilpatrick, Swafford, & Findell, 2001)
- Learning resources and strategies: with the human or non-human resources being provided, the way that students used for accomplishing the goal should be addressed in a SDL environment.
- The date for accomplishing the goal: the target date played an important role for accomplishing certain tasks. An appropriate date affected the learning effectiveness and it might reflect student's status for knowledge acquisition.
- Evidence: after students learned with the aforementioned elements for learning contracts, they should present or demonstrate the process or materials that related to the accomplishment for the learning task.
- Assessment: advisors such as teachers, capable peers, or students themselves should validate the feasibility for the learning contract and they should check whether the learning contract was reasonable for the students to work on.

On the other hand, Brookfield (1985) and Moore (1973) also agreed that the autonomous of a learner should be provided with mechanisms for the learner to follow and to learn. Brookfield mentioned an empirical study that adult learners would mostly to be a field independent learner, which focused on the expert knowledge that associated with more inclined to self-directness. Nevertheless, as we believed that there would be field dependent and field independent adults; there could be learners that would not be able to learn autonomously, especially children. Consequently, there needs a mechanism to assure learner's autonomous learning process is effective and to make sure the external resources could be accessible. In a later work, Gibbons' (2002) perception of SDL is similar to Knowles but differ in terms of adolescent's motivation and self-assessment. He also defines SDL as a progressive pedagogy, which helps elementary school teachers overcome the difficulties for applying SDL in classrooms. The SDL elements he proposes consist of:

- Students should be able to control the experience for their learning;
- Students skill development;
- Students achieve the best performance by additional challenges;
- Student's self-management;
- Student's self-motivation and self-assessment.

Due to the various similarities, we adopt the SDL framework which encompasses the common beliefs underlying SDL and common elements across various prior researches. However, in school learning, choice would not be the one and only index that assess student's motivation (choice of tasks, effort, persistence, achievement) (Schunk, Pintrich, & Meece, 2008). Tan, Shanti, Lynde, Cheah (2011) addressed issues on teachers' experience, such as classroom management, teacher's professional training, assessment ... etc. More attention should be focused on teacher's professional developments.

3. Design

This study followed the design in Chen, Liao, Cheng, Yeh, & Chan (2012). Chen et al. let the students take math learning missions that were designed based on the formal curriculum in public schools. For each unit in the curriculum, the learning activities were packaged into math missions, which were placed in the learning platform. Moreover, in addition to the design by Chen et al., this study helps

students to take the missions from the learning platform, manage their own learning and determine the number of missions that based on their goal setting before the learning activities began. Students would strive for their own defined learning goals and learn through math learning missions with or without the assistance of talented companion or classroom teacher independently. In this study, this study develops a 3-element framework that consolidates the essence of self-directed learning. The 3-element framework includes interactive content, learning contracts for goal setting, and monitoring & reflection.

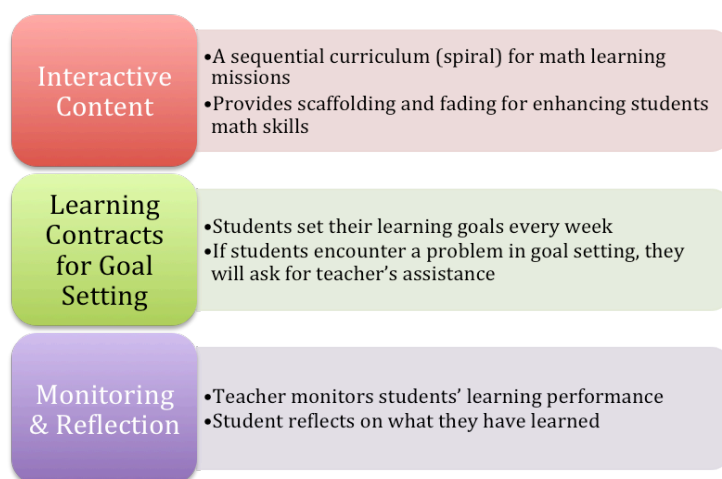


Fig 1. The 3-element framework for SDL.

3.1 Interactive content

The interactive content integrates the public school curriculum in an interactive way. From the spiral math curriculum in public schools, this study builds and enhances the current math learning knowledge into a more effective way. The design of this study follows and extends the K-W-L framework, which consisted of “What I Know”, “What I Want to Learn”, and “What I Learned” (Ogle, 1986). “What I Know” stands for the knowledge from the past experience, which might be learned in the last class, or common knowledge that happened beforehand. “What I Want to Learn” implies students’ desire for new knowledge. And “What I Learned” demonstrated what the students learned. Therefore, this study provides scaffolding and fading for students interact with the math knowledge with the use of their personal PCs. More specifically, this study would let the students to review, to learn, and to revise:

- Review: recalling the knowledge from last unit that might help understand the incoming math concept;
- Learn: understanding the math concept by scaffoldings and fading;
- Revise: practicing the knowledge that was learned, and trying to accept challenging questions from the similar math concept.

3.2 Learning Contracts

For the learning contracts in SDL, students have to set their learning goals in the first day of every week. Students would review the pace in the last 4 weeks (1 month), which was used as the reference for the goal setting this week. In order to help students review their previous effort in learning, the system would automatically count every student’s number of missions and performance, and it would suggest a suitable goal for the student’s to achieve. If students encounter a problem in goal setting, they will ask for teacher’s assistance. The teacher would be acknowledged in the teacher monitor. S/he would be able to help diagnose the student’s problem, provide appropriate suggestions, and come to a common agreement with the student.

3.3 Monitor & Assessment

In this study, both teachers and students were able to diagnose and reflect the learning performance through the learning platform. Due to the fact that system recorded every answer made by the students, teachers would easily monitor the learning progress for every student in their own classes, and they could actively or passively provide suitable assistance for the students who encountered a problem. Besides, students would also reflect what they had learned before the learning activities began. They could also decide whether accepting additional challenges such as complex problems, logical trainings (such as Sudoku), and small games for additional drill-and-practice exercises.

4. Results

The demand for understanding how student becomes self-regulated learners is appealing. Zimmerman (2008) showed that questionnaire and interviews were able to successfully predicting the student's learning outcomes. It reflects the internalization and personal regulations (Ryan & Deci, 2000). For exploring factors that help predict student's learning outcomes, factors that affecting the self-directness are being discussed. More specifically, such self-directness may be driven extrinsically by rewards, or grades, or intrinsically carried by the student's willingness, interest or engagement (Vrugt & Oort, 2008). Therefore, in order to explore the elements for personalized learning, we applied and modified Motivated Strategies for Learning Questionnaire (MSLQ) for exploring elementary student's internal motivation (Pintrich, 1991). This study follows the criteria in Motivated Strategies for Learning Questionnaire (MSLQ), where modified questionnaires were delivered to students before and after the system was applied, for the analysis of motivation for self-directed learning. The result of the questionnaire shows the orientation toward the learning activity, the level of participation, and the perception of active involvement (Pintrich, 1991). In this study, based on the pre-test for achievement and the criteria in MSLQ, students are divided into high/low achievement groups. High achievers reached an above-average score in the pre-test, and consequently low achievement students got a below-average score. Students with different learning capabilities show exceptional experimental results in different capability of achievements. High achievement students showed a significant difference with the low achievement students.

In this study, we delivered 58 questionnaires to the students, and 32 effective samples were returned and were used for the data analysis. As showed in Table 1, results in the first criteria showed that high achievement students had significant differences from low achievements in four different ways. Compared to low achievement students, high achievement students expected a higher performance for learning and task accomplishments (Criteria 1, $p < .05$). It addressed the issues that high achievement students were more likely to run for the success in learning tasks, and they were more eager to master the learning task than low achievement students (Cleary, 2006). The result is also consistent with the study by Stephenson, Poissant, & Dade (1999). Stephenson et al. pointed out that high achievers had higher cognitive abilities and achieved a greater efficiency than low achievers. As a result, it might due to the fact that most people strived for personal goal by the individual perception, which was based on their capabilities, and therefore a higher self-efficacy would result a higher learning achievement. As a result, high self-efficacy students set a higher goal than the low achievement students. High self-efficacy students had a higher commitment to learn (Bandura, 1991), and they had a higher awareness, knowledge and control of cognition than low achievers (Criteria 2, $p < .05$). It implied that high achievement students were more sensitive on the corresponding learning task, and they would demand for a higher level of knowledge acquisition. For this reason, Collins (1982) selected children with 3 levels of mathematic ability (high, mid, low). She compared these 3 levels of students to the students who had self-doubts on learning, and students were assigned to solve difficult problems. She found that students with high perceived self-efficacy would choose a more accurate solution than low perceived self-efficacy students. A similar work by Lei, Wang, & Tanjia (2002) showed that high achievers had a higher self-regulation. It was believed that students who owned more successful experiences in learning would enhance the intrinsic motivation, which might promote students' self-regulation ability (Boekaerts, Pintrich, & Zeidner, 2000). Therefore, the result also indicated that low self-efficacy students performed poorly because they lacked certain skills or the sense of self-efficacy as they lacked confidence to apply effective strategies for problem solving.

Table 1: Statistical comparison based on high/low achievement students.

Criteria		mean	s.d.	d.f.	t	sig.
1. Self-efficacy for learning & performance	High	4.421	.701	17.940	2.159	.045*
	Low	3.641	1.166			
2. Metacognitive self-regulation	High	4.005	.743	30	2.587	.015*
	Low	3.254	.895			
3. Intrinsic goal orientation	High	4.513	.524	30	4.307	.000***
	Low	3.346	1.003			
4. Resource management strategies: time and study environment	High	4.281	.739	16.143	2.135	.048*
	Low	3.333	1.478			

* $p < .05$, *** $p < .001$

In table 1, a significant difference for intrinsic goal orientation existed between high and low achievement students. This showed that the design of this study would help high achievement students achieved a higher intrinsic goal orientation than the low achievement students (Criteria 3, $p < .001$). It also implied that high achievement students were more engaged in the learning task, and s/he considered the participation in the learning task as a challenge, curiosity or mastery (Pintrich, 1991). The significance difference for high achievement students addressed the issue that most students desired for a higher learning goal, and they were more focused on the goal accomplishments. Moreover, in the study by Bandura & Schunk (1981), they described that the intrinsic goal orientation was positively related to the strength of self-efficacy in arithmetic activities. As a result, the higher self-efficacy, the higher intrinsic goal orientation was showed in the learning task.

Besides, for resource management strategies in table 1, it described the student's perception on the goal pursuance, the time management and regulation. In the classroom of a public school, most teachers dominated the classroom learning, in which they determined what was learned, and students would learn under supports or guidance by teachers (Deci, Schwartz, Sheinman, & Ryan, 1981). After class, students learned under the assistance or control by parents, where most parents concerned about the assessment, lecture revision, or encouragement in learning. Ryan & Deci (2000) pointed out that the parent's intervention provided stronger effects on engagement and performance for low achievement students, and low achievement students were more benefited from the parent's use of control than high achievement students.

Concerning the effect by the control of parents, a study by Pomerantz (2001) showed that high achievement students might own a higher personal value than low achievement students, and the control by parents might emphasize on the depression for high achievement students' competence and the application of help-seeking strategies (Corno, 1986; Ryan & Pintrich, 1998; Zimmerman & Martinez-Pons, 1988). Therefore, the aforementioned studies showed more positive results on low achievement students (parent's use of control) and negative results on high achievement students (depression). However, in this study, a significant difference was found in the resource management strategies between high achievement and low achievement students. As showed in table 1, the result indicated that high achievement students had a better planning, monitoring and regulation than low achievement students (Criteria 4, $p < .05$). The reason to this phenomenon might due to high expectations from parents, teachers or peers (Seginer, 1983; Weinstein, 2002), or the use of control and autonomy support by parents (Black & Deci, 2000; Guay, Boggiano, & Vallerand, 2001).

5. Discussion

The goal of this study is to reveal and discuss the possible factors that affect student's personalized learning. Although this study provides an analysis for the high and low achievers, we believed that analyses for the learning outcomes, the effects for different levels of intrinsic or extrinsic motivation, and individual's perception for the learning activities. More discussions should be addressed in further studies. However, in order to explore the elementary student's motivation factors for personalized learning. This study provides a preliminary analysis for student's personalized learning. By applying

SDL in regular classrooms, a Motivated Strategies Learning Questionnaire (MSLQ) was used to analyze the factors that affect student's learning motivation. Result indicates that high achievers were more beneficial than the low achievers, where high achievers showed significant differences in self-efficacy for learning & performance, metacognitive self-regulation, intrinsic goal orientation and resource management strategies: time and study environment with low achievers. High achievers showed a higher self-regulation that led to effective decisions for learning goals, which related to the mastery of knowledge, skills or values. Compared to the high achievers, the reason to the phenomenon for low achievers may due to the low motivation or interest, low context awareness, low confidence or non-effective goal settings.

Acknowledgements

The authors would like to thank the National Science Council of the Republic of China, Taiwan, for the financial support (NSC-101-2631-S-011-002, NSC-101-2511-S-008-016-MY3, NSC-100-2511-S-008-013-MY3, NSC-99-2511-S-008-002-MY3, NSC-101-2811-S-008-009, NSC-101-2811-S-008-010), and Research Center for Science and Technology for Learning, National Central University, Taiwan.

References

- Bandura, A., & Schunk, D. H. (1981). Cultivating competence, self-efficacy, and intrinsic interest through proximal self-motivation. *Journal of personality and social psychology*, 41(3), 586.
- Black, A. E., & Deci, E. L. (2000). The effects of instructors' autonomy support and students' autonomous motivation on learning organic chemistry: A self-determination theory perspective. *Science education*, 84(6), 740-756.
- Boekaerts, M., Pintrich, P. R., & Zeidner, M. (Eds.). (2005). *Handbook of self regulation*. Access Online via Elsevier.
- Boggiano, A. K., Barrett, M., Weiher, A. W., McClelland, G. H., & Lusk, C. M. (1987). Use of the maximal-operant principle to motivate children's intrinsic interest. *Journal of Personality and Social Psychology*, 53(5), 866.
- Brookfield, S.D. (Ed.) (1985). *Self-directed learning: from theory to practice*. San Francisco, CA: Jossey-Bass.
- Chen, Z. H., Liao, C. C. Y., Cheng, H. N. H., Yeh, C. Y. C., & Chan, T. W. (2012). Influence of game quests on pupils' enjoyment and goal-pursuing in math learning. *Educational Technology & Society*, 15(2), 317-327.
- Cleary, T. J. (2006). The development and validation of the self-regulation strategy inventory—self-report. *Journal of School Psychology*, 44(4), 307-322.
- Cleary, T. J., & Chen, P. P. (2009). Self-regulation, motivation, and math achievement in middle school: Variations across grade level and math context. *Journal of School Psychology*, 47(5), 291-314.
- Corno, L. (1986). The metacognitive control components of self-regulated learning. *Contemporary Educational Psychology*, 11(4), 333-346.
- Covington, M. V., & Omelich, C. L. (1985). Ability and effort valuation among failure-avoiding and failure-accepting students. *Journal of Educational Psychology*, 77(4), 446.
- Deci, E. L. & Ryan, R. M. (1985). *Intrinsic Motivation and Self-Determination in Human Behavior*. New York: Plenum Press Publishing Co.
- Deci, E. L., Schwartz, A. J., Sheinman, L., & Ryan, R. M. (1981). An instrument to assess adults' orientations toward control versus autonomy with children: Reflections on intrinsic motivation and perceived competence. *Journal of Educational Psychology*, 73(5), 642-650.
- diSessa, A. A. (2000). *Changing Minds*. MIT Press, Cambridge, MA.
- Dweck, C. S. (1986). Motivational processes affecting learning. *American psychologist*, 41(10), 1040.
- Gibbons, M. (2003). *The self-directed learning handbook: Challenging adolescent students to excel*. Wiley.com.
- Guay, F., Boggiano, A. K., & Vallerand, R. J. (2001). Autonomy support, intrinsic motivation, and perceived competence: Conceptual and empirical linkages. *Personality and Social Psychology Bulletin*, 27(6), 643-650.
- Hargreaves, D. (2004). *Personalising Learning: Next Steps in Working Laterally*, www.schoolsnetwork.org.uk/uploads/documents/4402.pdf
- Hargreaves, D. (Ed.) (2005). *About learning: report of the Learning Working Group* (London, Demos).
- Kilpatrick, J., Swafford, J., & Findell, B. (Eds.). (2001). *Adding+ it up: Helping children learn mathematics*. National Academies Press.

- Knowles, M. S. (1975). *Self-directed learning: A guide for learners and teachers*. Englewood Cliffs: Prentice Hall/Cambridge.
- Knowles, M. S., Holton III, E. F., & Swanson, R. A. (2012). *The adult learner*. Routledge.
- Lei, L., Wang, L., & Tanjia, C. (2002). Comparative study of self-regulated learning between high achievers and low achievers. *Psychological Development and Education*, 2, 6-11.
- Moore, M. G. (1973). Towards a Theory of Independent Learning. *Journal of Higher Education*, 44(12), 661-679.
- Ogle, D. M. (1986). KWL: A teaching model that develops active reading of expository text. *The Reading Teacher*, 39(6), 564-570.
- Pintrich, P. R. (1991). A manual for the use of the Motivated Strategies for Learning Questionnaire (MSLQ).
- Pomerantz, E. M. (2001). Parent× child socialization: Implications for the development of depressive symptoms. *Journal of Family Psychology*, 15(3), 510.
- Renninger, K., & Hidi, S. (2002). *Student interest and achievement: Developmental issues raised by a case study*.
- Ryan, R. M. & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, 55, 68-78.
- Ryan, A. M. & Pintrich, P. R. (1998). Achievement and social motivational influences on help seeking in the classroom. In S. A. Karabenick (Ed.), *Strategic help seeking: Implications for learning and teaching* (pp. 117–139). Mahwah, NJ: Erlbaum.
- Schunk, D. H., Pintrich, P. R., & Meece, J. L. (2008). *Motivation in education: Theory, research, and applications*. Englewood Cliffs: Merrill/Prentice Hall.
- Seginer, R. (1983). Parents' educational expectations and children's academic achievements: A literature review. *Merrill-Palmer Quarterly*, 29, 1–23.
- Stephenson, R., Poissant, H., & Dade, M. O. (1999). *Third graders' Self-regulation and self efficacy in a concept formation task: differences between low and high achievers*. ERIC Clearinghouse.
- Tough, A. (1979). *The adult's learning projects: A fresh approach to theory and practice in adult learning*. Toronto: Ontario Institute for Studies in Education.
- Vrugt, A., & Oort, F. J. (2008). Metacognition, achievement goals, study strategies and academic achievement: pathways to achievement. *Metacognition and Learning*, 3(2), 123-146.
- Weinstein, R. S. (2002). *Reaching higher: The power of expectations in schooling*. Cambridge, MA: Harvard university Press.
- Wolters, C. A., Yu, S. L., & Pintrich, P. R. (1996). The relation between goal orientation and students' motivational beliefs and self-regulated learning. *Learning and Individual Differences*, 8, 211–238. doi:10.1016/S1041-6080(96)90015-1.
- Zimmerman, B.J. & Martinez-Pons, M. (1988). Construct validation of a strategy model of student self-regulated learning. *Journal of Educational Psychology*, 80, 284-290.

Cognitive Styles and Hybrid Mobile Systems

Chen-Wei HSIEH & Sherry Y. CHEN*

*Graduate Institute of Network Learning Technology
National Central University
Jhongli, Taiwan
sherry@cl.ncu.edu.tw

Abstract: Mobile learning, which has become widespread in educational settings, faces students with diverse background, in terms of knowledge, skills and needs. Two approaches, i.e., Customization and Personalization, can be applied to sort out diversity. However, these two approaches have different advantages and disadvantages. Thus, this study tends to make best use of the advantages of personalization and customization to modeling a Hybrid Mobile Learning System (HMLS). In addition, Cognitive styles were considered as targets to investigate how cognitive styles affect students' reactions to the HMLS. The results show that the Holists attempted to use multiple tools, and the Serialists prefer to focus on a single item at a time. In addition, customization was helpful for Holists, while the personalization were useful for Serialists. The implications of these results for the design of Hybrid mobile learning system are discussed.

Keywords: Guidelines, formatting instructions, author's kit, conference publications

1. Introduction

Mobile learning has become increasingly popular in educational settings. The major reason for such popularity is that mobile learning systems offer many advantages, e.g., portable size of mobile tools, blended, private, interactive, collaborative, and instant information (Ozdamli & Cavus, 2011). Thus, mobile learning was generally considered as a useful tool, which can improve learners' performance (Yi, Liao, Huang & Hwang, 2009). However, there is a great diversity among learners, who may have heterogeneous backgrounds, in terms of their knowledge, skills and needs (Chen & Macredie, 2010). Thus, individual differences are essential issues.

There are two approaches to accommodate students' individual differences. One is to provide adaptability while the other is to offer adaptivity. The main difference between adaptability and adaptivity is that the former provides a customized program where learners are allowed to modify the content presentation and navigation facilities by themselves while the latter offers a personalized program where a system automatically adapts to learners based on observed behaviors (Stephanidis, Savidis & Akoumianakis, 1995). These two approaches differ with respect to who takes the initiative: the learner or the system (Kay, 2001). Customized systems are learner-controlled while personalized systems are system-controlled (Finlater & McGrenere, 2004). Giving the control to the learners can reduce the effect of incorrect adaptation. However, the cost of the increased controllability is the additional effort required from the learners. The learners may need to learn the adaptation component before being able to manipulate it (Tsandilas & Schraefel, 2004). In brief, these two approaches have different advantages and disadvantages. Thus, this study tends to make best use of the advantages of personalization and customization to modeling a Hybrid Mobile Learning System (HMLS).

Furthermore, an empirical study was conducted to investigate how cognitive styles affected students' reactions to the HMLS. Cognitive style refers to an individual preferred and habitual approach to organizing and representing information (Riding & Rayner, 1998). Cognitive styles were considered as targets because they have been recognized as being an important human factor affecting student learning. For example, Clewley, Chen and Liu (2011) found that Serialists and Holists had different preferences for their navigational styles. The former prefer to follow a linear pattern by having a suggested route or looking at the subject content step-by step with back/forward buttons. Conversely,

the latter tend to take a non-linear pattern by ‘jumping’ between different levels of subject contents with hypertext links. In brief, the ultimate aim of this study is not only to develop the HMLS, but also to get a complete understanding of how cognitive styles affect students’ reactions to HMLS.

2. Methodology Design

To effectively achieve the aforementioned aim, an empirical study was conducted. This section describes the methodology design of the empirical study, including participants, research instruments, experimental procedures and data analyses.

2.1 Participants

30 undergraduate and postgraduate students from some universities in Taiwan participated in our study voluntarily. A request was issued to students in lectures, and further by email, making clear the nature of the studies and their participation. All participants had the basic computer and Internet skills necessary to use a Hybrid Mobile Learning System (HMLS) described in Section 2.2.1 but they do not any understanding of the subject content of the HMLS.

2.2 Hybrid Mobile Learning System

Table 1 summarizes the different preferences of Holists and Serialists based on the results obtained in our previous study (Hsieh and Chen, 2013). This table was further applied to develop the HMLS, which included two versions. Figure 1 illustrates the design layout of the Serialist version, in which major navigation tools are the main menu and keyword search and the reading tools are located on the right side and the searching tools on the left side. Conversely, Figure 2 illustrates the design layout of the Holist version, in which major navigation tools are the main menu and previous/next buttons and the reading tools are located on the left side and the searching tools on the right side. The same content was used for both Holist and Serialist Versions without incurring the practice and fatigue effects in the study.

Table 1: Summary of Preferences of Holists and Serialists

	Serialists	Holists
Navigation Tools	The main menu and keyword search.	The main menu and previous/next buttons.
Display Formats	The reading tools on the right side and the searching tools on the left side.	The searching tools on the right side and the reading tools on the left side.

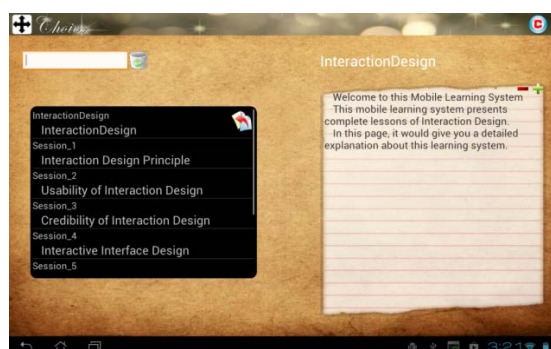


Figure 1. Serialist Version of HMLS (Initial Layout)



Figure 2. Holist Version of HMLS (Initial Layout)

In addition, learners were allowed to customize the look and toolbar based on their particular needs. The HMLS provides 10 kinds of tools, including Keyword, Main menu, Alphabetical Index, Topic, Content, Image, Route, History, Next & Previous, and Undo & Redo. In other words this system also allows learners to change the display formats and choose the navigation tools based on their particular needs. On the other hand, learners can also go back to use the navigation tools and display format provided in the Serialist version (Figure 3) or Holist version (Figure 4).



Figure 3. Serialist Version of the HMLS (Customized Layout)



Figure 4. Holist Version of HMLS (Customized Layout)

2.3 Task Sheet

When interacting with the HMLS, the participants were given a task sheet, which described the tasks that learners needed to perform. The range of tasks aimed to: (i) maintain the learners' motivation (Scanlon, 2000) and (ii) guide learners to search keyword to find information from the HMLS. Moreover, these tasks were used to assess learning performance. More specifically, how much time the participants spent for completing the tasks was applied to measure their learning performance.

2.4 Pre-test and Post-test

The pre-test and post-test were conducted to assess participants' levels of knowledge of the subject domain both before and after using the systems. The pre-test gave an objective assessment of the participants' prior knowledge of the subject domain. It included 20 multiple-choice questions, each with three different answers and an "I don't know" option. The post-test was designed to assess how much they have learnt from the HMLS. The post-test was presented in a computer-based format and included 20 multiple-choice questions. Each question included three different answers and an "I don't know" option but there was only one right answer. The questions covered all eight sections of the HMLS from basic concepts to advance topics.

2.5 Experimental Procedures

There were two scenarios and four stages in this Study. In order to identify students' reactions to the HMLS, a between-subjects design was used. In other words, each student used either the Holist Version or the Serialist Version based on their cognitive styles. Thus, each participant was initially provided with the SPQ to determine whether s/he was Holists or Serialists.

The participants were then asked to, carefully; go through a pre-test to measure their initial levels of knowledge. In the next stage, all participants were initially instructed how to use the tools provided by the HMLS. After they finished the pre-test, they were required to interact with the HMLS. At the same time, the participants needed to complete the practical tasks based on each question described in a task sheet. The time that they spent for completing the task was recorded in a log file. Then, learners needed to take a post-test, which was used to evaluate their learning performance based on the differences between the scores of post-test and the scores of pre-test. Finally, the participants were provided with a questionnaire to express their opinions to the use of the HMLS.

2.6 Questionnaire

The questionnaire was divided into two parts in this research. The first part focused on background information, such as age, gender, academic background, and the frequencies of mobile device/Internet usage, etc. In particular, it focused on their system experience, and enjoyment of using mobile device, and mobile learning programs, for example, how frequently they used mobile device and mobile learning and how much they enjoyed using the mobile device and mobile learning. The second part was committed to realize students' reactions to the HMLS. The questionnaire in this study included 40 questions. All of questions were designed based on five Likert Scale, which consisted of: "strongly agree", "agree", "neutral," "disagree" and "strongly disagree". Students were required to indicate agreement or disagreement with each question that most closely reflected their opinions. To reduce the bias of this research, there are an almost equal number of positive statements and negative statements.

3. Results and Discussions

3.1 Holists

3.1.1 Learning Behavior

As shown in Figure 5, most of Holists (78%, N=14) changed the original layout while only few of Holists (22%, N=4) unchanged the original layout. We further compare the participants who change the display formats with those who change navigation tools. More specifically, the results indicated that a great number of Holists (N=14) changed their navigation tools while only a few number of learners changed their display formats (N=3). It implies that the display formats originally provided by the Holists version in which the searching tools were put on the right side and the reading tools on the left side was suitable for their learning. On the other hand, navigation tools originally provided by the Holists version may not be helpful enough for them. One possible interpretation is that Holists tend to use additional materials to help them generate hypotheses and make inferences. Thus, they may expect to use a variety of navigation tools to make analogies, illustration and anecdote.

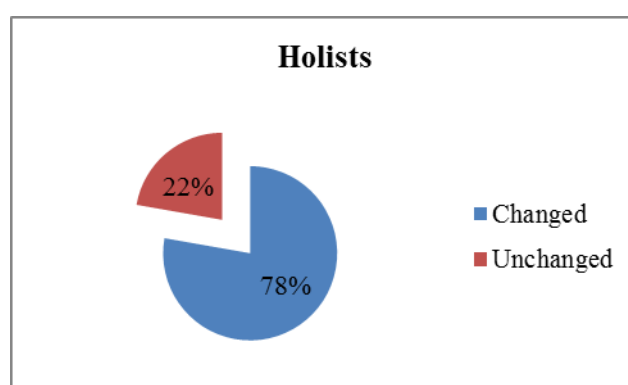


Figure 5. The Distribution of Layout Changed (Holists).

To further investigate how the Holists changed the original layout, the changed and unchanged navigation tools are discussed in this section. As shown in Figure 6 and Figure 7, in general, Holists frequently used the Main Menu and Previous & Next buttons. After comparing Figure 6 and Figure 7 in details, an interesting difference, however, was found. More specifically, Holists who changed the navigation tools and those who unchanged the navigation tools demonstrate different navigation behavior. The frequencies of using the Main menu in the former (54%) is high than those in the latter (35%). Conversely, Holists who changed the navigation tools less frequently used the Previous & Next buttons (37%) than those who unchanged the navigation tools (65%).

More specifically, Holists may prefer to use the Main menu, rather than the Previous & Next buttons. This is probably because that the Main menu allows learners to locate the information with "topic" based learning, which help Holists easily get a global picture and jump from one point to another in pursuit of their goals. These finding echoes that showed in Ford et al. (2002), which Holists

feel more comfortable with “topic” based learning. In brief, Holists attempted to use multiple tools to build their own navigation strategies instead of putting an emphasis on the particular navigation tools.

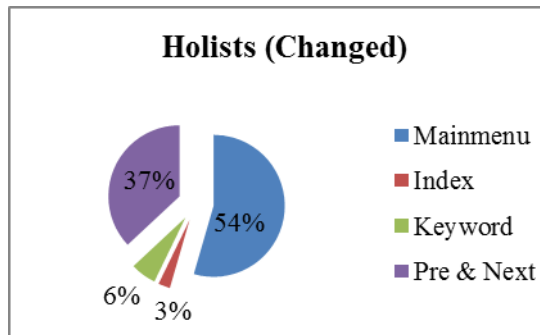


Figure 6. The Distribution of Navigation Tools

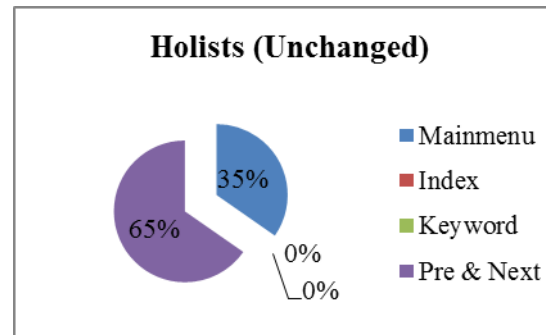


Figure 7. The Distribution of Navigation Tools

3.1.2 Learning Performance

As showed in Table 2, Holists who changed the navigation tools and those who unchanged the navigation tools have similar pre-test scores and obtained similar post-test scores and gain score. However, the former obtained the higher task scores but they spent more amount of task time than the latter. In other words, a huge amount of time that they spent for completing tasks is meaningful to them. This may be because Holists tend to spent more time exploring the learning environments and use additional supports to re-organize information to locate relevant information. Such finding also echoes the one described Section 3.1.1, which indicated Holists prefer to use additional material to help them generate hypotheses and make inferences. In other words, the HMLS was helpful for Holists to make best use of learning strategies to complete the tasks.

Table 2: Learning Performance of Changed and Unchanged

Attributes	Changed	Unchanged
	(N = 15)	(N = 3)
Pre-test Scores		
Mean (SD)	9.8 (2.38)	10.67 (2.21)
Task Scores		
Mean (SD)	20.4 (1.44)	18.33 (1.33)
Post-test Scores		
Mean (SD)	14.33 (1.13)	14.67 (1.52)
Gain Scores		
Mean (SD)	4.53 (2.77)	4 (1)
Task Time		
Mean (SD)	62.27 (5.97)	56 (4)

3.1.3 Learning Perception

As shown in Table 3, positive perceptions and negative attitudes were measured based on the favored statements and the non-favored statements, respectively. After comparing the perceptions of the Holists who changed the navigation tools with those who unchanged the navigation tools, we found that the former obtained higher scores for both the favored statements and non-favored statements than the latter. One possible reason is that HMLS allowed learners to modify the content presentation and navigation facilities by themselves. Such a way matches with characteristics of Holists, who attempted to use multiple tools to build their own navigation strategies, instead of putting an emphasis on the particular navigation tools (Section 3.1.1). In other words, default tools originally displayed in the HMLS were not so helpless for them, who were not satisfied with such a scenario.

Table 3: Learning Perception of Changed and Unchanged

	Changed	Unchanged
	(N = 15)	(N = 3)
Positive Perceptions		
Mean (SD)	3.99 (0.75)	3.70 (0.73)
Negative Attitudes		
Mean	2.9 (1.11)	2.44 (1.16)

3.2 Serialists

3.2.1 Learning Behavior

Unlike Holists' navigation behavior, most of Serialists (75%, N=9) prefer to use the navigation tools and display formats originally provided by the Serialist version (Figure 8). In other words, only a few number of Serialists (25%, N=3) changed the layout of the Serialist version. This may be because Serialists tended to focus on one thing at a time (Pask, 1976). Thus, Serialists may pay more attention to examining the subject content and ignore the layout of the HMLS.

It is also interesting to note that all of them change the navigation tools and nobody modifies the display formats. These findings suggest that the display format originally provided by the Serialist version is suitable for their learning. This may be because Serialists prefer to take restricted navigation (Ford and Chen, 2000). Thus, they tend to use a static learning environment, instead of a dynamic a learning environment where navigation tools and display formats can be changed.

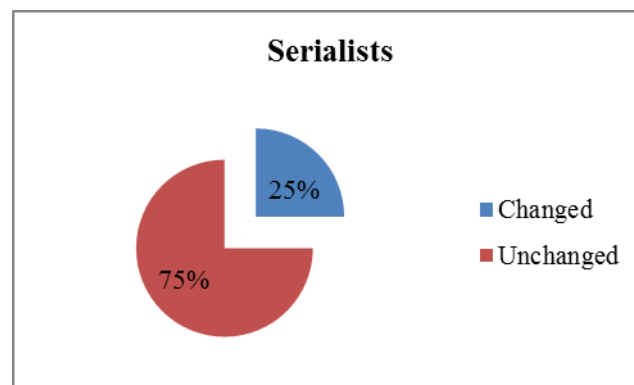


Figure 8. The Distribution of Layout Changed (Serialists).

To further investigate how these three Serialists changed the original layout, the navigation tools used by them were examined. As shown in Figure 9 and Figure 10, Serialists prefer to use the Main menu and Keyword search. Moreover, it was also found that Serialists used the Main menu more often than the Keyword search. More specifically, the main menu is useful for them to browse the subject content page by page while the keyword search can help them find specific information for their particular needs. This may be because Serialists tend to take a sequential approach so they need to rely on the main menu to examine the content step by step. On the other hand, they emphasized on procedural details (Pask, 1976) so it is necessary for them to acquire the details with the keyword search.

Additionally, Serialists only used the Previous & Next buttons (5% and 0%), Index (1% and 0%) and Keyword search (12% and 11%) a few times, but they used the Main menu (82% and 89%) many times. This finding implies that Serialists mainly use the Main menu, regardless of those who changed the navigation tools and those who unchanged the navigation tools. This may be due to the fact that Serialists prefer to focus on a single item at a time. In summary, Serialists not only use the navigation tools that can match with their characteristics, but also tend to rely on a single navigation tools at a time.

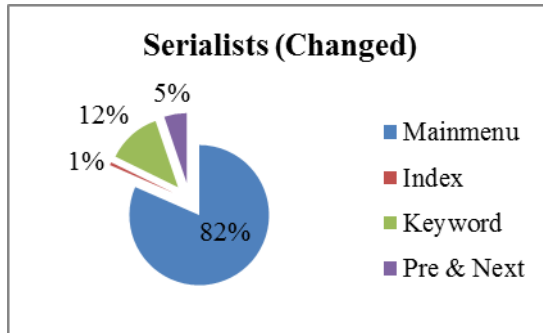


Figure 9. The Distribution of Navigation Tools

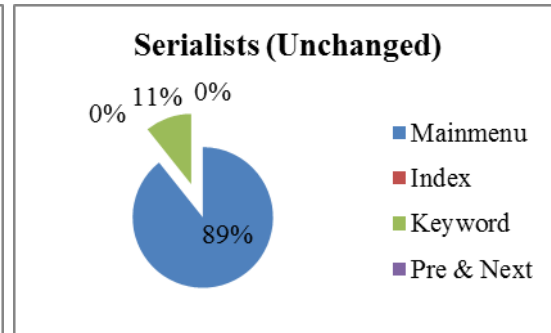


Figure 10. The Distribution of Navigation Tools

3.2.2 Learning Performance

Table 4: Learning Performance of Changed and Unchanged

Attributes	Changed	Unchanged
	(N = 3)	(N = 9)
Pre-test Scores		
Mean (SD)	10.00 (1.68)	10.22 (1.39)
Task Scores		
Mean (SD)	19.67 (1.47)	19.22 (1.41)
Post-test Scores		
Mean (SD)	13 (1.6)	13.67 (1.41)
Gain Scores		
Mean (SD)	3 (1.00)	3.44 (0.94)
Task Time		
Mean(SD)	57.33 (4.08)	57.78 (3.62)

As showed in Table 4, Serialists who changed the navigation tools and those who unchanged the navigation tools obtained similar pre-test scores and similar task Scores, post-test scores and gain scores. Furthermore, they also spent a similar amount of time completing the tasks. It may be because Serialists who changed the layout did not spend too much time to select additional navigation tools and arrange the display formats in the HMLS. One possible interpretation is that navigation tools and display format provided in the Serialist version was suitable for them. Such finding also echoes the one described Section 3.2.1, which indicated that Serialists tend to take restricted navigation within a static learning environment.

3.2.3 Learning Perception

As shown in Table 5, positive perceptions and negative attitudes were measured based on the favored statements and the non-favored statements, respectively. After comparing the perceptions of the Serialists who changed the navigation tools with those who unchanged the navigation tools, we found that the both of them obtained similar scores for the favored statements and non-favored statements. In other words, they showed similar perceptions. As described in Section 3.2.2, Serialist version was suitable for them and they did not make too changes for the layout. This may be the reason why Serialists who changed the navigation tools and those who unchanged the navigation tools had similar perceptions.

Table 5: Learning Perception of Changed and Unchanged

Changed	Unchanged

	(N = 3)	(N = 9)
Positive Perceptions		
Mean (SD)	3.75 (0.52)	3.60 (0.84)
Negative Attitudes		
Mean	2.78 (0.76)	2.79 (0.88)

4. Conclusions

This study developed a HMLS, with which we examined how cognitive styles affects learners' reactions to mobile learning. In general, the results demonstrated that Holists attempted to use multiple tools to build their own navigation strategies, instead of putting an emphasis on the particular navigation tools. Conversely, Serialists tended to rely on a single navigation tools at a time. In addition, the results also demonstrated that customization was helpful for Holists while personalization was useful for Serialists.

These experimental results can be used to construct robust user models, which can be used to describe the requirements of different cognitive style groups. In brief, the present study shows fruitful results but there are several limitations. Firstly, the present study only incorporates a small-scale sample and limited navigation tools. Hence, it is recommended that further studies should be undertaken with a larger sample, so that additional evidence can be obtained.

Acknowledgements

References

- Chen, S. Y., & Macredie, R. (2010). Web-based interaction: A review of three important human factors. *International Journal of Information Management*, 30(5), 379-387.
- Clewley, N., Chen, S. Y. & Liu, X. (2011) Mining Learning Preferences in Web-based Instruction: Holists vs. Serialists. *Educational Technology & Society*. 14 (4), 266-77.
- Ford, N., Wilson, T.D., Foster, A., Ellis, D. & Spink, A. (2002), "Information seeking and mediated searching. Part 4. Cognitive styles in information seeking", *Journal of the American Society for Information Science and Technology*, Vol. 53 No. 9, pp. 728-35.
- Ford, N., & Chen, S. Y. (2000). Individual differences, hypermedia navigation and learning: An empirical study. *Journal of Educational Multimedia and Hypermedia*, 9(4), 281-311.
- Finlater, L., & McGrenere, J. (2004). A comparison of static, adaptive, and adaptable menus. In *Proceedings of CHI 2004*.
- Hsieh, C. W. & Chen, S. Y. (2013). The Effects of Cognitive Styles on Mobile Learning: Adaptability vs. Adaptivity. *Proceedings of the AECT International Conference on the Frontier in e-Learning Research 2013*.
- Hsieh, C. W., Chen, S. Y. (2013). The Effects of Cognitive Styles on Mobile Learning: Adaptability vs. Adaptivity. *AECT International Conference on the Frontier in e-Learning Research 2013*
- Kay, J. (2001). Learner control. *User Modeling and User-Adapted Interaction*, 11(1/2), 111-127.
- Ozdamli, F., & Cavus, N. (2011). Basic elements and characteristics of mobile learning. *Procedia-Social and Behavioral Sciences*, 28, 937-942.
- Pask, G. (1976). Styles and strategies of learning. *British Journal of Educational Psychology*, 46, 128-48, 1976.
- Riding, R., & Rayner, S.G. (1998), *Cognitive styles and learning strategies: Understanding style differences in learning and behavior*. London: David Fulton Publisher.
- Scanlon, E. (2000). How gender influences learners working collaboratively with science simulations. *Learning and Instruction*, 10(6), 463-481.
- Stephanidis, C., Savidis, A., & Akoumianakis, D. (1995). Towards user interfaces for all. In *Conference proceedings of second TIDE congress* (pp. 167-170).
- Tsandilas, T., & Schraefel, M. C. (2004). Usable adaptive hypermedia systems. *New Review of Hypermedia and Multimedia*, 10(1), 5-29.
- Yi, C.-c., Liao, P.-w., Huang, C.-f., & Hwang, I.-h. (2009). Acceptance of mobile learning: a respecification and validation of information system success.

Collaborative Problem-Solving Learning Supported by Semantic Diagram Tool: From the View of Technology Orchestrated into Learning Activity

Huiying CAI, Bian WU & Xiaoqing GU*

Department of educational information technology, East China Normal University, China

**xqgu@ses.ecnu.edu.cn*

Abstract: Collaborative problem-solving learning (CPSL) refers to constructing knowledge and developing problem-solving abilities in the process of solving domain problems in a collaborative manner. Acting as a breakthrough of transforming traditional knowledge-centered instruction, CPSL has received great attention by international researchers in education. Currently, how technology can be used to support and facilitate the process of collaborative problem-solving remains the key research question. Therefore, our research team conducted a field study to investigate how technology can be really orchestrated into CPSL. A semantic diagram tool was integrated in primary school science class in Shanghai. This paper reports our second-round design-based research to answer two research questions: (1) How can the semantic diagram tool be integrated in classroom to support social interaction and collaborative problem solving; and (2) What are the major learning activities in the semantic diagram tool-supported CPSL. Video data collected in the whole CPSL project was analyzed using coding analysis method. The study reveals that, from technological perspective, semantic diagram tool can be combined with other technology to support the process of CPSL and, from instructional perspective, learning goal should be extended and learning activities should be redesigned and refined according to the extended learning goal when semantic diagram tool is orchestrated into CPSL. Besides, the style of student activity and teacher's role can be changed in the semantic diagram tool-supported CPSL.

Keywords: CPSL; technology orchestrated into learning; instructional activity; classroom analysis

1. Introduction

Collaborative problem-solving learning (CPSL) refers to constructing knowledge and developing problem-solving abilities in the process of solving domain problems in a collaborative manner (Stahl et al., 2006; Guet al., 2011). A large number of studies reveal that CPSL can improve student problem-solving skills, self-learning ability and deep understanding about knowledge (Lohman & Finkelstein 2000). However, some researchers found that in the process of collaborative problem-solving, students may encounter a variety of social and learning challenges, such as lack of structural knowledge, collaborative strategies and self-regulation abilities, to name but a few (Wegerif, 2006; Ge & Land, 2003; Jonassen et al., 1997). In the face of those challenges, this study aims to propose an innovative instructional design solution that integrates semantic diagram tool to support CPSL in the classroom.

2. Literature review

Previous studies often focus on two-fold of instructional intervention to support CPSL that is collaboration and problem-solving (Guet al., 2011; Ge & Land, 2003). However, CPSL is often lack of effective guidance or support in formal classroom teaching, especially in social and meta-cognitive aspects such as group development and self-regulation (Clark et al., 2012), making collaboration a mere

formality, which in turn, may fail to reach the desired learning goals. Semantic diagram tool can be designed for supporting CPSL in an effective way. It makes use of graphics, images, animations and other visual elements to characterize the abstract knowledge, such as the concepts, principles and concept relations (Gu, 2013). In this study, a semantic diagram tool called Metafora platform was selected. Metafora platform is a web-based platform for science and math education. It can be used to visualize collaborative problem-solving process, promote collaboration and facilitate organization of learning activities (Dragon et al., 2013). In this study we used two tools in the Metafora platform. One is called Planning tool that provides a set of icons called Visual Language Cards to represent different steps in the collaborative problem-solving process so that learners can make working plans by using these cards. The other tool called LASAD is a dynamic concept-mapping tool for argumentation.

Although semantic diagram tool has many pedagogical advantages, it is difficult to integrate in classroom teaching effectively. Integrating technology in the process of teaching and learning requires a systematic adjustment by teachers which will bring additional teaching burden (Zhao & Frank, 2003). Also, there is a lack of domain-dependent pedagogical knowledge to align tool use in CPSL. It seems a gap between macro-level teaching guidance, such as lesson mode or teaching plans and micro-level instructional support in a particular teaching situation (Prieto et al., 2011a). Further, teachers should not only pay attention to the learning outcome of general teaching, but also make the appropriate instructional feedback and evaluation for different levels of collaborative learning process by using appropriate technology or teaching techniques (van Leeuwen et al., 2013). These bring challenges for teachers to organize teaching and learning activities through integrating technologies in the classroom.

3. Methodology

3.1 Design-based research

Design-based research method (Brown, 1992) was adopted in this study to (1) analyze the practical problems in CPSL in the classroom; (2) propose and implement the instructional design that focuses on semantic diagram tool-supported CPSL; and (3) to analyze the learning process of CPSL to understand the impact of technology integration in learning. This study reports the instructional design process and some preliminary findings of the second round DBR.

The first-round study reveals that the external pre-lecture affordances (such as collaborative skill training lesson before class begin, make a plan making for problem solving before learning task begin and teacher's instructive guidance before class begins and so on) for group's CPSL can promote group interaction, although well-organized so as to develop group's collaborative problem-solving skills of students remain in a surface level. Therefore, this second-round study focuses on how to give internal within-class affordance for the process of CPSL. In order to help student develop student's collaborative problem-solving learning competence is our main research goal in the second round study.

In this study we chose the Metafora platform as a semantic diagram tool to support the process of problem solving and collaboration, considering the tool can not only create learning space to motivate students to learn together, but also facilitate student reflection on the learning process through visualization. Specifically, this study focuses on two-fold, that is how to design effective instructional strategies to integrate the semantic diagram tool in CPSL in the classroom and how the tool actually affords interactions and problem-solving process. Two research questions are proposed accordingly.

Question 1: *How can the semantic diagram tool be integrated in classroom to support social interaction and collaborative problem solving?*

Question 2: *What are the major learning activities in the semantic diagram tool-supported CPSL?*

3.2 Research context and participant

The study was conducted in a primary school in Shanghai. The science teacher we collaborated with has more than 10 years of teaching experience. She is open-minded in adopting innovative instructional approach and has positive attitude to apply ICT into classroom. Twenty-one students in the fourth grade were randomly assigned into 5 groups. The classroom was equipped with PCs, Internet access, electronic projector and Metafora learning platform.

4 Instructional design and coding analysis

4.1. Instruction design framework

Orchestrating technology into learning activity is not a simple process of adding technology on learning. Technology should be integrated into the classroom with a clear goal about how they will support teaching and learning activities and how these activities fit into the overall curriculum (Baloian et al., 2000). Therefore, a holistic design for orchestrating semantic diagram tool in a CPSL session is proposed by aligning tool functionality with learning goals and instructional strategies (see Fig. 1).

Continuing the research design in the first-round study, we designed four aspects research intervention strategies including group collaboration skills training (Dawes, 2004; Wegerif & Mansour, 2010), problem-solving plan making (Jonassen, 1997), learning tip offering to facilitate group discussion (Cho & Jonassen, 2002) and promotion of evidence-based discussion of students (Ge & Land, 2003; 2004) to achieve the learning goal of facilitating social interaction and developing problem-solving competence in CPSL.

As functionality of the semantic diagram tool is considered, LASAD can guide students in expressing and visualizing their ideas on a shared space in the real time. Therefore, we intent to use LASAD in two aspects, i.e., take rules and express attitude, to achieve the learning goal of collaborative problem-solving skill development. Similarly, by using the representing icon in the Planning tool, students can make plans for the problem-solving process. During the process of planmaking, discussion about which icon should be placed in a certain step for solving the problem is reflected in a generated concept map. Instructional strategies of question prompts and structuring the evidence-based argument are adopted to support student collaborative problem-solving learning.

In order to orchestrate the intervention from both the research and technological perspectives, we designed instructional strategies in a behavioral level. We set up some warm-up activities at the beginning of the learning session in order to teach students how they can do collaborate problem solving. Also in the warm-up activities, we combined the exercises for collaborative skill and problem-solving skill development with those for getting familiar with Metafora platform. By doing the warm-up activities, we aim to reduce the workload of using the semantic diagram tool in CPSL. After the warm-up activities, we intent to follow the problem-solving process of problem definition and analysis and organize learning activities by orchestrating the learning technology (i.e., LASAD and Planning tool).

4.2 Learning content and activity design

Through discussing with the science teacher, nutrition and digest from the science textbook of Grade 4 was selected as the learning topic. Based on analysis the learning content of this unit, we designed five sequential learning points, namely, (1) classify the given foods based on the type of nutrition; (2) detect the main nutrition composition of given food; (3) discuss the function of certain type of nutrition; (4) survey and evaluate one's family's diet during one week; (5) develop a healthy diet plan for the family. The instructional design framework was then applied in the detailed design of each learning activity as shown in Table 1.

Table 1: Learning Content and Activity Design

Sess-ion	Pedagogical Objectives	Pedagogical activity	Tools
1	Warming-up activity 1: Understand the collaborative skills; Get familiar with the LASAD tool	Teacher introduces LASAD ; Student classify the rule of collaborative skill on the LASAD in order to make them understand and know collaborative skill	LASAD
	Point 1: Classify the given foods based on the type of nutrition	Ask students in group to confirm a criterion how to classify the food based on the data of nutrition ingredient; Let student in group express their ideas why they classify food according to the criterion on the LASAD	
2	Warm-up activity 2: Understand the process of solving-problem; Get familiar with the Planning tool	Introduction of Planning tool ; Explain student that we should first make a plan confirming the stage and process when solving a problem	Planning tool
	Point 2: detection the main nutrition composition of given food	Let student to make a plan for how to detection the starch in food on the Planning tool in advance; Make a experiment for detection the starch in the selected food; Ask students in group to reflect and remix their plan according to the real experiment	
	Hands-on activity for point 4	survey one's family's diet during one week	—
3	Point 3: discuss the function of certain type of nutrition	Assign different learning materials about introduction of nutrition and let every group to express their each understanding about the function of nutrition ingredient on the LASAD; Let every group report one's discussion result in the class level	LASAD;
4	Point 4: survey and evaluate one's family's diet during one week;	Each groups select one of diet which the member in group provided and evaluate it based on the result of shared activity about understanding the function of certain type of nutrition on the LASAD;	LASAD;
	Point 5: Develop a healthy diet plan for family	Based on the evaluation every group discuss in group how to develop a healthy diet plan by using of Planning tool and LASAD.	LASAD; Planning tool

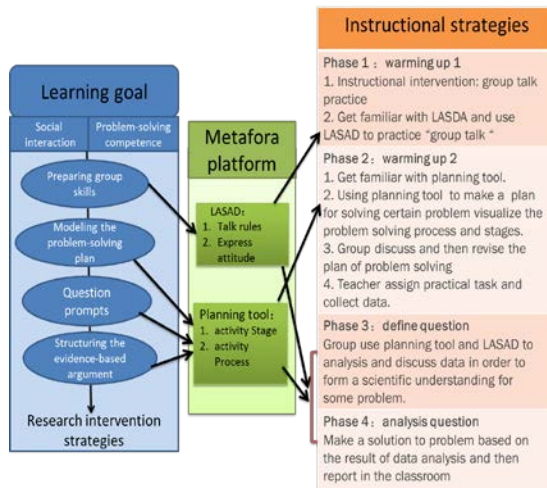


Figure 1. Instruction Design Framework

4.3 Data collection and analysis method

In order to answer the two research questions, we analyze the whole class videos collected in this study using coding analysis approach. The video data recorded the whole class activity which lasted four sessions (35 minutes per session). In order to understand what really happened in the classroom, our research team members worked together to transcribe the video record into text according to what the teacher said word by word and what the students did in the class. After finishing the transcription, we adopted two types of coding scheme to analyze the text data to answer those two research questions.

Table 2: Coding Scheme Example for the Whole Class Activities

Time	Role	Discussion content	Label the activity	Coding the meaning of activity
13:55	T	Today we will learning something about food and nutrition(wrote in the blackboard). Firstly, I want to ask you what question you would like to ask when you see these words?	Teacher's activity	5. Introduce learning topic
	S1	Which food do it point to?		
	S2	Which nutrition do food contain?		
	T	Ok. Which nutrition do food contain? It is means that different food contain different nutrition. Today, that is the content we are going to research.		
15:03	T	Next I will assign a table into every group which show names and amount different types nutrition of food. I hope when your group get the table, read it seriously and tell me what you find out. ok? After every group finish their discussion, I will let you report your finding group by group.	Teacher's activity	6. distribute learning materials and assign group discussion task
15:10	G	Start to discussion	Student's activity	7. Group discussion
19:02	G	End up discussion		

To answer the first research question of how to integrate semantic tool into instructional activity in the collaborative problem-solving learning, we should depicting the context of how to orchestrate technology into learning activity. Because every instructional activity with single goal can be viewed as

a unit distinguished from other instruction activity(Prieto et al., 2011b), we use a complete undivided learning activity in the classroom as a coding unit and then make a qualitative coding scheme for the class video section which was shown a certain instructional meaning from the teacher and student activity perspective. The scheme example is shown in Table 2.

Table 3: Coding Scheme of Teacher's Activity, Students' Activity and Technology

Role	Activity items	Meaning of item	Example of activity	Coding picture
Teacher's activity	explain	Transmits necessary knowledge to the students	1. Intruduce group rule; 29. Review how to make a plan by planning tool	
	support	Give certain or support for learning activity;	6.Distribute materials and assign group task 15.Show experiment tool	
	evaluate	the results of tasks are evaluated	20. Conclusion for experiment	
Student's activity	Discuss	discuss learning task	2. Discuss group rules 10. brainstorming	
	Report	report learning task	3.Group report	
	other	Other student's activity	13.Observe experiment firstly	
technology	Technological support	technology used in a certain learning task	LASAD was used in the activity 2	

To answer the second research question of what the major learning activities are in the semantic diagram tool-supported CPSL, we coded learning activities from the perspective of teacher and student activities. The analysis of classroom activity integrated with technology should reflected the interactions among teacher, students and technology because technology integrated into instruction and learning process not only bring new learning material into classroom but also contribute to the transformation of learning style, instructional method and interaction way between teacher and student (Gu, 2004). Specifically, we distinguished three types of teacher activity (explanation, support and assessment) and three types of student activities (group discussion, group report and others) according to the characteristic of this study. The coding scheme is adapted based on the scheme designed by Prieto et al. (2011b) and shown in Table 3.

4.4 Results and discussion

Question 1: How can the semantic diagram tool be integrated in classroom to support social interaction and collaborative problem solving?

According to the rule of scheme example in Table 2, there are 35 units of instructional activities coded from the class video. Then we made a diagram of teacher and student activities and technologies used in the class. The x-axis is the time line and the y-axis is the learning goals. The visualized result of instructional activity in the whole learning project is shown in Fig. 2. The grey box in Fig. 2 representing certain learning activity indicates the step in which technology was used.

After analyzing the Fig. 2, three findings are obtained. First, we can find in the process of orchestrating semantic diagram tool into learning activities, the tool combines with other traditional learning technology, such as focused materials, designed worksheet and prepared laboratory items give support for collaborative problem-solving process from a technological perspective. Therefore, we believe that traditional learning technology and digital learning technology can coexist in the class to support the learning process. To some extent, the findings infer that different learning activities with certain goals should be supported by different learning technologies, that is, single learning technology cannot play the whole role in support of the whole class activities. Second, comparing the traditional learning goal set in advance with those achieved in the study, we can find that in the process of orchestrating semantic diagram tool into learning activities, learning goals are extended. We held that the extension of learning goals can offer learning technology the integrated space and value to

orchestrate into the learning process. Third, compared with the traditional instructional design without using semantic tool, we can see that learning activities are redesigned and refined according to the extended learning goal. Specifically, teacher should transform instructional philosophy of what to teach into how student learn and how we can use technology to support the learning process in practice which conforms to the student-centered instructional idea.

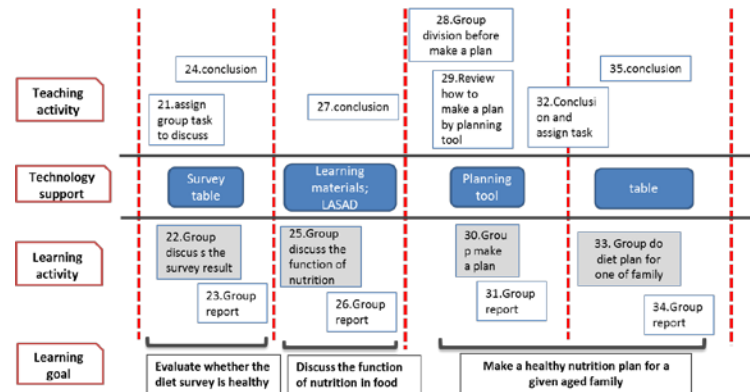


Figure 2. A Part of The Diagram for the Whole Class Activities Based on the Coding Scheme in Table 2

Question 2: What are the major learning activities in the semantic diagram tool-supported CPSL?

Based on the metaphor of orchestration (Fischer & Dillenbourg, 2006), we coded the video data again into the transition diagram of instructional activity according to the type of teacher and student activity, the type of interaction (in the individual level, in the group level and in the class level) and the use of technology to visualize clearly the structure of how technology can be orchestrated into CPSL process. The coding result is shown in Figure 3.

As can be seen in Figure 3, group report activity and group communication activity took up 11/35 (31%) and 8/35 (23%) of all classroom activities, respectively. These two types of student-centered learning activities took up over one half (19/35) in all. Compared with the traditional teacher-centered lecturing approach, there was obvious transfer towards student-centered learning in this semantic diagram tool-supported CPSL. Further within all teacher-centered activities, support activities took up 7/16 (43.75%), whereas assessment and explanation activities took up 6/16 (37.5%) and 3/16 (18.75%). The findings reveal that in the collaborative problem-solving learning, the teacher played a role of learning facilitator rather than knowledge transmitter or classroom dominator. And the unique function of technology orchestrated into learning process is to promote and to catalyze the change of learning activity and teacher's role in the class.

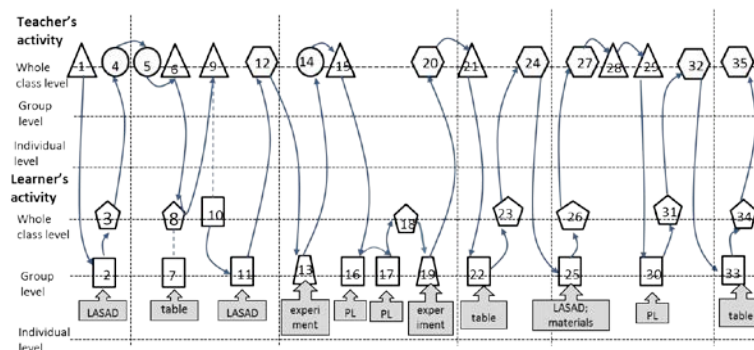


Figure 3. The Diagram for the Whole Class Activities Based on the Coding Scheme in Table 3

5. Conclusion

In this paper, a whole class case of orchestrating technology to support the process of CPSL is reported focusing on the instructional design and coding analysis of learning process based on the design-based research method. From the macro-level perspective, we held that learning technology orchestrated into CPSL is a complex progress, which contains the technological design and implementation, learning activity design and organization and content analysis of learning process in a real setting. From the micro-level perspective, we concluded that, in order to support the process of CPSL, technology should be orchestrated into learning with the goal of developing domain-knowledge and collaborative problem-solving competences that is to offer learning technology an integrated space and value in the learning process and organize learning activities in line with instructional philosophy of how students learn and how we can use technology to support the learning process in real practice.

This study focuses on how to orchestrate semantic diagram tool to support CPSL from the viewpoint that technology can be effectively orchestrated in classroom learning activities. However, whether the semantic diagram tool-supported CPSL can produce positive learning outcome compared with traditional lecturing and how this innovative instructional design actually affect student learning behavior change remain unknown. Therefore, further research is required on these questions.

Acknowledgements

We would like to thank for the science teacher from Shangahi who took part in this round field study. She coordinated with our research team to co-design classroom activities. And we also would like to thank for people who prepared and revised previous versions of this document.

Reference

- Brown, A. L. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *The journal of the learning sciences*, 2(2), 141-178.
- Baloian, N. A., Pino, J. A., & Hoppe, H. U. (2000). A teaching/learning approach to CSCL. Paper presented at the System Sciences, *Paper presented at the 33rd Annual Hawaii International Conference*.
- Cho, K. L., & Jonassen, D. H. (2002). The effects of argumentation scaffolds on argumentation and problem solving. *Educational Technology Research and Development*, 50(3), 5-22.
- Clark, R. E., Kirschner, P. A., & Sweller, J. (2012). Putting Students on the Path to Learning--The Case for Fully Guided Instruction. *American Educator*, 6-11.
- Dawes, L. (2004). Talk and Learning in Classroom Science. *International Journal of Science Education*, 26 (6) 677-695.
- Dragon, T., Mavrikis, M., McLaren, B., Harrer, A., Kynigos, C., & Wegerif, R., et al. (2013). Metafora: A web-based platform for learning to learn together in science and mathematics. *IEEE Transactions On Learning Technologies*.
- Fischer, F., & Dillenbourg, P. (2006). Challenges of orchestrating computer-supported collaborative learning. *Paper presented at the 87th Annual Meeting of the American Educational Research Association (AERA)*, San Francisco, California, USA.
- Ge, X., & Land, S. (2003). Scaffolding students' problem-solving processes in an ill-structured task using question prompts and peer interactions. *Educational Technology, Research and Development*, 51(1), 21-38.
- Ge, X., & Land, S. (2004). A conceptual framework for scaffolding III-structured problem-solving processes using question prompts and peer interactions. *Educational Technology Research and Development*, 52(2), 5-22.
- Gu, X. Q. (2013). The theory and practice research on presenting and modeling of visual knowledge by semantic diagram tool. *The research program application report funded by the National Science Education "1025" planning*. (in Chinese)
- Gu, X. Q., & Wang, W. (2004). The exploration research on analysis of classroom activity supporting for teacher's professional development. *China Educational Technology*, 7:18-21. (in Chinese)
- Gu, X. Q., Guo, X. F., & Cai, H. Y. (2011). Research on Learning in a Scientific Way: Connecting the Theory and Practice of CSCL. *Modern Distance Education Research*. (05), 15-22. (in Chinese)
- Jonassen, D. H. (1997). Instructional design models for well-structured and III-structured problem-solving learning outcomes. *Educational Technology Research and Development*, 45(1), 65-94.

- Lohman, M.C. & Finkelstein, M. (2000). Designing groups in problem-based learning to promote problem-solving skill and self-directedness. *Instructional Science*, 28, 291 – 307.
- Prieto, L. P., Villagr -Sobrino, S., Dimitriadis, Y., Schank, P., Penuel, W. & DeBarger, A. H. (2011a). Mind the gaps: Using patterns to change everyday classroom practice towards contingent CSCL teaching. *Paper presented at the 9th International Conference of Computer-Supported Collaborative Learning*, Rhodes, Greece.
- Prieto, L. P., Villagr -Sobrino, S., Jorr n-Abell n, I. M., Mart nez-Mon s, A., & Dimitriadis, Y. (2011b). Recurrent routines: Analyzing and supporting orchestration in technology-enhanced primary classrooms. *Computers & Education*, 57(1), 1214-1227.
- Stahl, G., Koschmann, T., & Suthers, D. (2006). Computer-supported collaborative learning: An historical perspective. In R. K. Sawyer (Ed.), *Cambridge handbook of the learning sciences*. (pp. 409-426). Cambridge, UK: Cambridge University Press.
- Van Leeuwen, A., Janssen, J., Erkens, G., & Brekelmans, M. (2013). Teacher interventions in a synchronous, co-located CSCL setting: Analyzing focus, means, and temporality. *Computers in Human Behavior*, 29(4), 1377-1386.
- Wegerif, R. (2006). A dialogical understanding of the relationship between CSCL and teaching thinking skills. *International Journal of Computer-supported Collaborative Learning (ijCSCL)*, 1(1), 143–157.
- Wegerif, R., & Mansour, N. (2010). A dialogic approach to technology-enhanced education for the global knowledge society. In Khine, M. S. & Saleh, I. M. (Eds). *New Science of Learning: Cognition, Computers and Collaboration in Education* (pp 325-340). New York: Springer.
- Zhao, Y., & Frank, K. A. (2003). Factors affecting technology uses in schools: An ecological perspective. *American educational research journal*, 40(4), 807-840.

Comparative Research of ICT in Elementary Education Development Strategy in Developed and Developing Countries

Chun LU, Sha ZHU & Di WU*

National Engineering Research Center for E-Learning, Central China Normal University, China

** mr.wudi@163.com*

Abstract: ICT in education development strategy is an important part of educational strategy plan, which promotes the development of ICT in education. Scientific and rational planning of ICT in Education play an important role in promoting sustainable development of ICT in Education and exerting functional benefit of ICT in education. ICT in Elementary Education is an essential part of construction of ICT in Education, which is the core area that reflects the revolutionary impact of ICT on educational development. The paper, taking China, United States and Singapore as examples of developing country and developed countries, discussed the NETP2010 which was launched by U.S. Department of Education, the Master Plan 3 by Singapore Department of Education, and the Elementary Education part of “Ten-year development plan of ICT in Education(2010-2020)” by China Ministry of Education. Combined with the development demands and basic conditions of China, United States and Singapore, the paper compared and analyzed the features, similarities and differences of the three strategic plan of ICT in Elementary Education, and explored the difference of their construction background and development ideas. Finally, the paper proposed several suggestions for the developing countries like China to enhance the construction of ICT in Elementary Education.

Keywords: ICT in education, development strategy of ICT in education, ICT in Elementary Education, comparative research

1. Introduction

ICT can play a particularly important role in supporting education reform and transformation (Means & Olson, 1995; Means, et al., 2004). Faced with increasingly fierce competition, countries around the world regarded ICT in education strategy as a forward-looking choice to promote innovation and development of education, and enhance countries' comprehensive competitiveness. U.S. Department of Education(2010) launched the forth National Educational Technology Plan (Hereinafter refer to as “NETP2010”) in 2010, which is a typical and influential strategy plan in the field of ICT in Elementary Education. British Joint Information Systems Committee (2010) published the “JISC Strategy 2010-2012”. Japan Ministry of Education, Culture, Sports, Science and Technology (2011) published the “The vision for ICT in Education” in 2010, and Singapore (2008) released the “Master plan 3” in 2008. To deal with the fierce competition of integration of ICT and educational development, meet the actual needs of educational reform and development, and achieve the requirements of “National Long-term Educational Reform and Development Plan (2010-2020)”, China Ministry of Education (2012) released the “Ten-year development plan of ICT in Education(2010-2020)” (Hereinafter refer to as “Ten years' Plan”). The “Ten-year Plan” noted that ICT in Elementary Education is the cornerstone of improving national information literacy, and the top priority of ICT in Education (Ministry of Education, 2012). This paper selected the United States and Singapore as the two representative developed countries from Europe and Asia to compare with developing country of China, and analyzed the strategic objectives, core content and main projects of the three countries strategy plan of ICT in Elementary Education, which can not only figure out the development characteristics of ICT in Elementary Education in United States and Singapore, but also compare the differences of the overall development objectives and future development tasks among the two countries and China, and thus provide reference for the subsequent deployment and implementation of China “Ten-Year Plan”.

2. U.S. Strategy Plan of ICT in Elementary Education

NETP2010 called for revolutionary transformation of the educational system, and proposed the “A 21st Century Model of Learning Powered by Technology”, which presented five essential components including learning, assessment, teaching, infrastructure and productivity. The model identified goals in each area, which are the strategic goals of NETP2010.

- Learning: All learners will have engaging and empowering learning experiences both in and outside of school that prepare them to be active, creative, knowledgeable, and ethical participants in our globally networked society.
 - Revise, create, and adopt standards and learning objectives for all content areas to improve learning.
 - Develop and adopt learning resources that exploit the flexibility and power of technology to reach all learners anytime and anywhere.
 - Use advances in the learning sciences and technology to enhance STEM learning.
- Assessment: Our education system at all levels will leverage the power of technology to measure what matters and use assessment data for continuous improvement.
 - Give timely and actionable feedback about student learning.
 - Build the capacity to use technology to improve assessment materials and processes for both formative and summative uses.
 - Explore how gaming technology, simulations, collaboration environments, and virtual worlds can be used to assess complex skills and performances embedded in standards.
 - Ensure privacy and information protection while enabling a model of assessment that includes ongoing student learning data.
- Teaching: Professional educators will be supported individually and in teams by technology that connects them to data, content, resources, expertise, and learning experiences that enable and inspire more effective teaching for all learners.
 - Design, develop, and adopt technology-based content, resources, and online learning communities.
 - Provide pre-service and in-service educators with preparation and professional learning experiences powered by technology.
 - Leveraging technology to create career-long personal learning networks within and across schools, pre-service preparation and in-service educational institutions.
 - Use technology to provide access to the most effective teaching and learning resources, and to provide more options for all learners at all levels.
 - Develop a teaching force skilled in online instruction.
- Infrastructure: All students and educators will have access to a comprehensive infrastructure for learning when and where they need it.

- Ensure that students and educators have adequate broadband access to the Internet and adequate wireless connectivity both inside and outside school.
- Ensure that every student and educator has at least one Internet access device and software and resources.
- Leverage open educational resources to promote innovative and creative opportunities for all learners and accelerate the development and adoption of new learning tools and courses.
- Build state and local education agency capacity for evolving an infrastructure for learning.
- Support “meaningful use” of educational and information technology in states and districts by establishing definitions, goals, and metrics.
- Productivity: Our education system at all levels will redesign processes and structures to take advantage of the power of technology to improve learning outcomes while making more efficient use of time, money, and staff.
 - Develop and adopt a common definition of productivity in education and more relevant and meaningful measures of learning outcomes and costs.
 - Improve policies and use technology to manage costs including those for procurement.
 - Fund the development and use of interoperability standards for content, student learning data, and financial data to enable collecting, sharing, and analyzing data.
 - Rethink basic assumptions in our education system that inhibits leveraging technology to improve learning.
 - Design, implement, and evaluate technology-powered programs and interventions.

There are four influential projects on ICT in Elementary Education implemented in the U.S., as the Table 1 shown.

Table 15 Main projects on ICT in Elementary Education

No.	Project	Supporter
1	Technology Innovation Challenge Grants	Office of Innovation and Improvement
2	E-rate program	Federal Communications Commission
4	PT3 (Preparing Tomorrow's Teachers to Use Technology)	Teacher and Student Development Programs Service

Technology Innovation Challenge Grants was funded by the Office of Innovation and Improvement of U.S. During the five years of 2000 to 2004, the project had funded a total of 100 sub-projects, which covers curriculum standards, teacher professional development, network resources, computer-assisted instruction, educational technology impact assessment and other aspects.

In order to achieve the goal that each classroom can connect to the Internet in 2000, Clinton signed the "Telecommunications Act" and established the E-rate program in 1996, providing low-cost telecommunication fees to ensure each school and library can afford the advanced communications services.

The Department of Education's Preparing Tomorrow's Teachers to Use Technology (PT3) grant program addresses a growing challenge in modern education: nearly all elementary and secondary

schools are now "wired" to the Internet, but most teachers still feel uncomfortable using technology in their teaching. Since 1999, PT3 has awarded over 400 grants to education consortia to help address this challenge. These grants include projects designed to transform teaching and learning through: Faculty development, Course restructuring, Certification policy changes, Online teacher preparation, Enriched-Networked-Virtual, Video case studies, Electronic portfolios, Mentoring triads, Embedded assessments.

3. Singapore Strategy Plan of ICT in Elementary Education

Master Plan 3 (MP3) emphasized the use of information technology to enhance students' self-learning. MP3 proposed four major goals and corresponding content:

- Students develop competencies for self-directed and collaborative learning through the effective use of ICT as well as become discerning and responsible ICT users.
 - Self-Directed Learning: Ownership of Learning, Management and Monitoring of Own Learning, Extension of Own Learning.
 - Collaborative Learning: Effective Group Processes, Individual and Group Accountability of Learning.
- School leaders provide the direction and create the conditions to harness ICT for learning and teaching.
 - Develop and communicate shared ICT vision and goals that are aligned to the school's strategic thrusts and mp3 vision and goals
 - Establish targets and communicate expectations of the effective use of ICT in learning and teaching
 - Support the continuous professional learning and development of all teachers; align school resource management with student learning needs; engage stakeholders and industry to enhance support for student learning
- Teachers have the capacity to plan and deliver ICT-enriched learning experiences for students to become self-directed and collaborative learners, as well as nurture students to become discerning and responsible ICT users.
 - Establish Student-teacher learning partnership, promote students' self-management and monitoring of their learning, extend students' learning experiences, in order to promote self-directed learning.
 - Create multiple and appropriate platforms and networks to generate and promote collaboration among students; provide feedback on individual learning and group learning and performance
- ICT infrastructure supports learning anytime, anywhere.
 - ICT infrastructure has the capacity to respond to changing curriculum needs and the needs of individual schools based on their programmes and curriculum needs.
 - Provides full ICT capabilities and easy access to computing devices to support a range of learning and teaching needs.

- ICT infrastructure keeps pace with technological developments with minimum obsolescence.
- A range of technical support services is readily available to meet schools' needs.
- Every student will have access to a computing device with the necessary software, internet connection and learning resources to enable learning to take place from home.

There are six influential projects on ICT in Elementary Education implemented in Singapore, as the Table 2 shown.

Table 16 Main projects on ICT in Elementary Education

No.	Project	Topic
1	Program for Rebuilding and Improving Existing Schools	Infrastructure
2	FastTrack@School	Educational resources
3	LEAD ICT@Schools	ICT integration
4	Edvantage	Innovative ICT application
5	Cyber Wellness Student Ambassador Programme	Cyber wellness
6	The ICT Mentor Programme	Teachers' professional development

Program for Rebuilding and Improving Existing Schools was launched by the Singapore Ministry of Education to update and improve the hardware and IT equipment of old schools, and the program had invested 450 million dollars.

The FastTrack@School project encourages businesses and schools collaborate to develop online education resources, during the MP1 implementation period, the project had funded more than 300 interactive multimedia software and services projects.

Both the LEAD ICT@Schools project and Edvantage project were funded to support and promote schools' creative application of information technology at a higher level.

Cyber Wellness Student Ambassador Programme and The ICT Mentor Programme focused on cyber wellness and teachers' professional development respectively, which were implemented during the MP3.

4. China Strategy Plan of ICT in Elementary Education

The "Ten-year Plan" presented three goals in the field of ICT in Elementary Education. 1) Bridge the digital gap. 2) Promote the integration of ICT and teaching. 3) Cultivate students' learning abilities in ICT supported environment.

To achieve the three goals of ICT in Elementary Education, the "Ten-year Plan" put forward corresponding content. Core contents of ICT in Elementary Education of the "Ten-year Plan":

- Bridge the digital gap
 - Improve school's basic configuration level in infrastructure, teaching resources and software tools.
 - Promote teachers and students' use of digital teaching resources, open enough curriculum standard based courses, and enhance bilingual education in ethnic minority area.
 - Focus on supporting rural areas, remote and poor areas, ethnic minority areas' school information and public service system.
- Promote the integration of ICT and teaching
 - Build intelligent learning environment, provide high-quality digital educational resources and software tools.
 - Carry out heuristic, inquiry, discussion and participatory teaching using ICT.

- Encourage development evaluation, explore the establishment of learner- centered teaching mode.
- Advocate online interscholastic collaborative learning, improve the teaching level with ICT.
- Gradually spread network teaching research led by experts, improve teachers' learning relevance and effectiveness, and promote teachers professional development.
- Cultivate students' learning abilities in ICT supported environment
 - Continue to popularize and improve information technology education, carry out various ICT application activities, and create green, safe, and civilized application environment.
 - Encourage students to use information tools for active learning, independent learning and cooperative learning.
 - Cultivate students' good habits of using ICT to learn, develop interests and specialties, and improve learning quality.
 - Enhance students' abilities of asking and analyzing questions, and problem-solving skills in the network environment.

Furthermore, for the three goals, the "Ten-year Plan" proposed the "Development Frameworks of ICT in Elementary Education 2020".

- Improve school's basic configuration and application level of ICT construction
 - Availability of various ICT infrastructure and resources. Schools' leadership, teachers' application ability of educational technology, professionals' supportive ability.
 - Teachers, students and parents' satisfaction of ICT application.
- Schools' innovation of educational and teaching methods make breakthrough.
 - Teachers' habit of teaching with ICT.
 - Changes in Knowledge presentation, teaching evaluation, and organizational differentiated instruction.
 - Changes in student diversity and personalized learning.
- Enhance students' self-learning ability in ICT supported environment
 - Willingness to use ICT in learning.
 - Ability of using ICT to discover, analyze and solve problems.
 - Self-discipline to use ICT healthily.

There are three main projects on ICT in Elementary Education implemented in China, as the Table 3 shown.

Table 17 Main projects on ICT in Elementary Education

No.	Project	Topic
1	School-to-School project	Infrastructure
2	Class-to-Class project	Educational resources
3	People-to-People project	Personalized learning

In order to quicken the pace of the popularizing ICT in education in elementary and middle schools, China's Ministry of Education promulgated "the notification on implementation School-To-School Project in elementary and middle schools" and decided to organize and implement this project in 2000. It intends to make 90% of elementary and middle schools connect to the Internet to promote the balanced development of education within 5 to 10 year. The establishment of the School-to-School Project gives a firm protection to promote the balanced development of education caused by the historical, economic and political factors.

"Class-to-Class" is a project following the "School-to-School" project, which is a comprehensive program that blends infrastructure, software resources and ICT integration with

educational content. The goal of "Class-to-Class" is to realize the sharing of high-quality educational resources among classes.

"People-to-People" is a new project proposed based on the first two projects, which was launched by the "Ten-year Plan", and the aim of "People-to-People" project is to achieve personalized learning, that is, each student will have their own learning space which can connect with others.

5. Comparison of ICT in Elementary Education Development Strategy of China, United States and Singapore

After comparing the goals and core content of NETP2010, Master Plan 3 and "Ten-year Plan", it is easy to find out the similarities and differences of the ICT in Elementary Education strategy focus, as shown in Table 4.

Table 18 ICT in Elementary Education strategy focus of China, U.S. and Singapore

	"Ten-year Plan"	NETP2010	Master Plan 3
ICT infrastructure	√	√	√
Digital teaching resources	√	√	√
Learning assessment with ICT	√	√	
Application of ICT in teaching	√	√	√
Students learning ability with ICT	√	√	√
Educational productivity		√	

5.1 Similarities

In the above table, we can see that the ICT in Elementary Education strategy goals of U.S., Singapore and China have significant differences. However, there are three common features of the countries' goals: focusing on ICT infrastructure construction, emphasizing the application of ICT in teaching, paying attention to cultivate students' learning ability in ICT supported environment.

5.2 Differences

Firstly, the strategic goals of the NETP2010 is based on the systematic view, proposed the 21st Century Model of Learning Powered by Technology, and set the goals from the aspects of educational system including learning, assessment, teaching, infrastructure and productivity. Especially, the NETP2010 involved the educational productivity, which is not included in the Master Plan 3 and "Ten-year Plan".

Secondly, the Master Plan 3 embodied the educational idea of "Just for students' development". The four goals in the Master Plan 3 all served for developing students' competencies for self - directed and collaborative learning from the perspectives of students, teachers, schools and infrastructure. The outcome goal of the Master Plan 3 is for students to "develop competencies for self - directed and collaborative learning through the effective use of ICT and to become discerning and responsible ICT users" with a focus on anytime- anywhere learning (ICT Connection website). The three key enablers are: school leadership for providing direction, communicating that vision and creating a conducive environment with systematic support; teacher capacity to guide students and provide structures that allow for such experiences; and infrastructure, including Internet connectivity, within the school and at the Ministry level with opportunities for extension to the home for every student (Office of Educational Technology U.S. Department of Education, 2009).

Singapore has made a conscious choice to leverage ICT to enhance and enrich the learning experience of students in its education system. As the technologies advance, their use in education has become increasingly more pervasive and effective. The continual success in the use of ICT for teaching and learning will necessarily depend on a committed government that has the tenacity to see through the implementation of various ICT Master Plans in Education as well as the foresight to chart out future needs in this area (UNESCO, 2011).

Thirdly, goals of the “Ten-year Plan” reflected the special conditions and educational status of China. Uneven development of Elementary Education is a significant problem in Chinese education system, therefore, the “Ten-year Plan” emphasized on narrowing the digital gap between developed areas and underdeveloped areas in China ICT in Elementary Education. Furthermore, as the stages of ICT in Education of China is between the “emerging” and “applying”, integration of ICT and teaching is an important goal of the “Ten-year Plan”. However, as the U.S. and Singapore’ development level of ICT in education is much higher than China, the NETP2010 and Master Plan 3 pay more attention to the innovative application of ICT in teaching.

6. Discussion and Conclusion

Drawing upon the experiences of the NETP2010 and Master Plan 3, we may lead to the following lessons on developing ICT in Elementary Education, which may be also helpful for the countries like China that is investing more on ICT in education and lacking of enough experiences.

6.1 Political Support

Some educational policies are conceived at the highest level of the government. Often, these policies are presented as a national initiative that transcends educational goals, aiming, in the first place, to produce social and/or economic transformations and in a second place, to have an impact in students’ educational outcomes (UNESCO, 2011). Both countries of the U.S. and Singapore have strong political support on the development of ICT in Elementary Education, and the governments invested a lot money and resources to enhance the construction of ICT in Elementary Education.

6.2 Implementation Strategy

There are different strategies that can be used to implement ICT in education policies, they can differ in the way they are planned and managed, the structure used for its implementation and stages that countries follow to implement them. For example, Singapore, developed a very well structured, progressive approach to the implementation of its ICT in education policy, defining the phases, activities, products and responsible party for each step of the implementation. By implementing a feedback loop, results of each ICT master plan were analyzed in order to incorporate the lessons learned into the design of the subsequent one (UNESCO, 2011).

6.3 Teacher Professional Development

One of the key challenges in the successful implementation of the ICT master plan for education is ensuring teachers’ readiness in changing their classroom practices to integrate ICT into the curriculum in a meaningful manner. To succeed in the implementation, attention must be paid to the cultural or people dimension. Before most teachers will be willing to change their classroom practices, they need to be persuaded by realistic models of ICT-based pedagogies that demonstrate some transformation of the educational experiences of their students. As there may be a steep learning curve in the integration of ICT into the curriculum, most teachers will not be convinced to change their classroom practices if the application of ICT were to merely allow them to go about their teaching faster or to do more of the same. It is important to change teachers’ beliefs through the use of success stories that clearly demonstrate the value-adding impact of the use of ICT in teaching and learning (The International Bank for Reconstruction and Development, 2008). The pedagogical role of teachers is to structure and support these practices by providing resources and explicitly modeling cognitive and social processes and prompting students to take up these practices (Bransford, Brown, & Cocking, 2000; Blumenfeld, Kempler, & Krajcik, 2006; Krajcik & Blumenfeld, 2006).

6.4 Investment on ICT in Elementary Education

Adequate financial support is essential to the steady development of ICT in Education. The United States provided financial support through a number of policies and regulations, and establishing different levels of funding methods according to their national conditions. Singapore also invested a lot to ensure the construction of ICT in education, especially in the aspects of infrastructure, digital educational resources and teachers' professional development. During MP1 to MP3, Singapore had implemented a lot of projects to ensure the development of ICT in education. For the developing countries, adequate investment on ICT in Elementary Education is a more important thing, for the infrastructure in developing countries should be the priority, and it takes more money to equip enough ICT devices for schools, classrooms, teachers and students. In addition, educational resources and teachers' professional development are both important for the developing countries, which need large investments. So the author suggested that government should encourage the collaboration with private enterprises and stimulate their investment on the development of ICT in Education by policy support.

The breadth and depth of these ICT-supported emerging practices suggest that these trends will persist, if not accelerate and expand, in the coming decade. For ICT to play a supportive, beneficial role in improving education in the future, the most critical factor is whether or not educational leadership, at all levels, continues to address the policy issues as they emerge, including the need to develop the capacity for schools to be ICT-supportive learning organizations (International Association for the Evaluation of Educational Achievement, 2001.)

References

- Blumenfeld, P., Kempler, T. & Krajcik, J. (2006). Motivation and cognitive engagement in learning environments. In R. K. Sawyer (Ed.), *Cambridge Handbook of the Learning Sciences* (pp. 475-488). Cambridge: Cambridge University Press.
- Bransford, J., Brown, A., & Cocking, R. (2000). *How people learn: Brain, mind, experience, and school* (2nd ed.). Washington, DC: National Academic Press.
- Joint Information Systems Committee. JISC Strategy 2010– 2012 [DB/OL]. <http://www.jisc.ac.uk/aboutus/strategy.aspx>, 2012-07-12.
- Krajcik, J. & Blumenfeld, P. (2006). Project-based learning. In R. K. Sawyer (Ed.), *Cambridge Handbook of the Learning Sciences* (pp. 317-334). Cambridge: Cambridge University Press.
- Master Plan 3 [DB/OL]. <http://ictconnection.moe.edu.sg/cos/o.x?c=/ictconnection/pagetree&func=view&rid=665>, 2013-07-14.
- Means, B., Roschelle, R., Penuel, W., Sabelli, N., & Haertel, G. (2004). Technology's contribution to teaching and policy: efficiency, standardization, or transformation? In R. E. Floden (Ed.), *Review of Research in Education* (Vol.27). Washington, DC: American Educational Research Association.
- Means, B., & Olson, K. (1995). *Technology's role in education reform: findings from a national study of innovating schools*. Washington, DC.; Department of Education, Office of American Educational Research and Improvement.
- Ministry of Education, Culture, Sports, Science and Technology. (2011). The Vision for ICT in Education. Japan. National Long-term Educational Reform and Development Plan (2010-2020) [DB/OL]. http://www.moe.edu.cn/publicfiles/business/htmlfiles/moe/moe_838/201008/93704.html, 2012-07-12.
- Office of Educational Technology U.S. Department of Education. (2009). International Experiences with Technology in Education: Final Report.
- U.S. Department of Education, Office of Educational Technology. (2010). Transforming American Education: Learning Powered by Technology.
- The International Bank for Reconstruction and Development. (2008). Toward a better future: education and training for economic development in Singapore since 1965.
- International Association for the Evaluation of Educational Achievement. (2001). ICT and the Emerging Paradigm for Life-long Learning.
- UNESCO. (2011). Transforming Education: The Power of ICT Policies.

Diffusion of ICT in Education: Behavior Subjects, Dynamic Diffusion Model and Enhance Methods

Jinbao ZHANG

Beijing Normal University, China

Zhangjb@bnu.edu.cn

Abstract: This study examines the dynamic mechanic in the diffusion process of ICT in education. In this paper, the author analyzes the features of three participants (Innovators, Change Agents and Adopters) in the diffusion process of ICT in Education. The Innovators can also be divided into three types: Primary Innovators without market willingness, Flexible Innovators for special demand, and Integrated Innovators towards the marketplace. Early adopters have strong effect with other's potential adopters. Although there are many literates on adoption mode, little research is based on motivation analysis. In this paper, the author tries to bring forward a Dynamic Diffusion Model of ICT in education in order to explain the internal dynamic rules among these behavior subjects. In the end, we also discuss how to promote the internal forces in the diffusion process.

Keywords: Educational Technology, Diffusion, Dynamic Mechanism

1. Introduction

In this current age of rapid technological change, human beings are more than ever paying attention to education and learning in order to individual empowerment, cultural prosperity, social cohesion and economic development. ICT's main application in the past generation has been to raise productivity in the business sector by making it possible for workers and managers to access and process massive amounts of information. (Martin Carnoy, 2004)

As an important marketplace, more and more equipment and software have been made and be sold into schools. The industry declares it has the revolutionary effect of ICT in education. In the university sector, ICT has already made an important impact, whether in terms of teaching, research or administration. However, in the case of ICT in education, education managers are largely illiterate in information management tools. Likewise, despite schools having more and more access to ICT, new technologies are still scarcely used as part of the teaching methodology. There are few real examples with educational models that are based on this technology.

In order to address and cope with these challenges, schools continue to experiment with a variety of programs. As a result, many sophisticated and innovative change models have been implemented in schools. Some models, for example, aimed at bringing about positive changes in schools through improving teacher professional knowledge base and teaching repertoires. Other models focused on developing the capacities of local leadership. Still others attempted to develop innovative curricula for school change or to change the organizational structures and cultures in schools. As

different as these change models are, however, the success of any model depends on the motivation and capacities of the key agents who play a leading role in implementing school change. (Leithwood et al., 2004)

Research on the implementation and institutionalization of educational technology innovation is regarded as "the last mile", which determines the success or failure of research in practice. (Xudong Zheng, 2005) Recent theories and literatures can help to explain where, why and which technologies in education are adopted or rejected. (Holloway, R. E., 1997) However, we still don't know whether there is clear and stable dynamic mechanism. What are the characteristics of the technology diffusion system? How we can further enhance our dynamic mechanism? This article will focus on these issues.

2. Behavior Subjects in the Diffusion of Educational Technology

Diffusion is defined as the process by which (1) an innovation (2) is communicated through certain channels (3) over time (4) among the members of a social system. The four main elements are the innovation, communication channels, time, and the social system. (Rogers, E. M., 2003) However, additional complexity is added to the use of ICT in education by other external factors which may be technological, social, political, economic or psychological.

The successful diffusion should be both meeting the requirements of education and to covering certain range of schools. Some diffusion needs the drive of intermediary organizations, while others do not. Therefore, there are three subjects in the diffusion process, which are innovators, adopters and change agents. (see Figure 1) Change agents are those who introduce innovations into a society or organization.

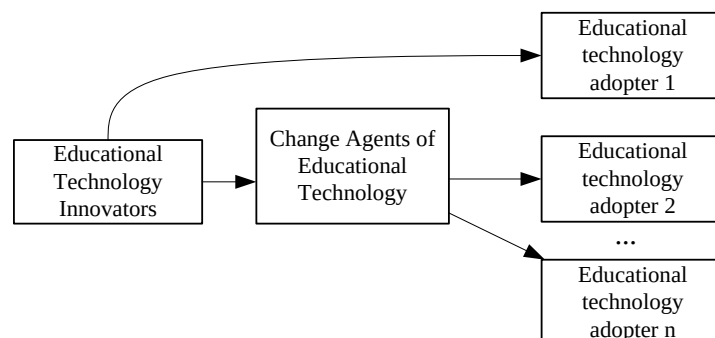


Figure 1. Behavior Subjects in the Diffusion Process of Educational Technology

2.1 Innovators of Educational Technology

Academic organizations mostly play the role of innovators in the system of the diffusion. The innovators of educational technology can be divided into three types:

(1)Primary innovators without market willingness. They are unable to package the concepts and products of educational technology in a market-oriented way, more is to achieve the introduction of integrated innovation or innovative work. The majority of majority of domestic research institutions of educational technology belong to that category;

(2)Flexible Innovators for special demand. They have the ability to put the products of educational technology they create or develop within the field of production, but the scale is often subject to certain restrictions. Most of them use the income of outcome transformation to continuously support the follow-up research activities, which is also called "market-supported research." In the

present case, there is a larger proportion of these organizations, some of which are successful academic teams of educational technology.

(3) Integrated Innovators towards the marketplace. They can both research and develop innovative educational technology products and have a strong external impact. In many cases, the innovation of educational technology first serves for its own needs, and at some point such kind of innovation is exported. This constitutes a very small proportion of academic organizations.

2.2 Adopters of Educational Technology

Schools and teachers are the main adopters of innovation. In China, since the 1990's, the top five pilot ICT in education projects are found that early adoption brings pressures to the similar district or schools, although sometimes the effect to the school's core business growth is not obviously, as long as the involved together with other schools will be able to share the potential "benefits" which are forcing many schools to actively participate. It is financial support by the central government that solves the funding issues to special schools those who cannot afford to. To some extent, that forces the urban schools should by themselves raise funds in different ways in order to improve the equipment, resources, and applications of educational technology, and etc. In addition, many successful adopters of educational technology (especially schools) were analyzed. It will undoubtedly be known: In some schools, the active innovation and the risk-taking spirit in applying educational technology, is largely because it can bring good students, good teachers and effective.

2.3 Change agents of the Diffusion of Educational Technology

During the last four decades, educational researchers and practitioners have intensively engaged in bringing about positive changes in schools. Therefore, the kinds of changes introduced to schools have become complex in nature and overwhelming in number. A large number of external agents — variously referred to as consultants, linking agents, education officers, or supervisors — have mobilized themselves for building schools' capacity and knowledge utilization at the local level. (Mir Afzal Tajik, 2008)

Change agents' role has been defined and described in variety's ways in the literature. Sometimes, their role is captured through the official job titles given to change agents; sometimes, it is portrayed through the strategic actions they take in schools; sometimes it is illustrated through descriptions of their political location and status in schools. The status of the diffusion intermediaries (diffusion facilitators, or change agents) are very obvious in the whole diffusion, because they can help to transmit information, facilitate the contact and communication between innovators and adopters, to assist the negotiations for the final transaction, and to achieve the transfer of outcomes of technology innovation. Evidence shows that most external change agents in the developed nations take on the specific roles such as process helper, resource linker, mediator, knowledge builder, capacity builder, practitioner, innovator, provocateur, and catalyst. (Leithwood, K., et al., 2004)

School reform is extremely complex for K12, due to the limitation of the national support, social awareness and other factors. So educational organizations do not have the drive and features of actively looking for change. Therefore, the position of diffusion change agents are extremely important in the diffusion process. Education usually is unable to make flexible changes. Thus, it is quite necessary and reasonable to take inter-transferring subjects as the important driving force.

3. Dynamic Diffusion Model of ICT in Education

Adoption is the process of finding the right tool for the job. It is one of the oldest and most important concepts in the diffusion-of-innovations (DOI) literature. (Eveland, J. D, 1979) It has been the focus of a mammoth body of research. Despite this abundant literature, there is still much about adoption that is poorly understood. In particular, the innovation diffusion literature has largely ignored decision psychology [6], [7] and has treated the causal aspects of adoption as a black box. Brent A. Zenobia et al (2009) lay the foundation for a comprehensive, step-by-step explanation of how events or life experiences cause a consumer's beliefs about a technology to change over time. They give rise to the Motive-Technology-Belief (MTB) framework, a theory that conceives of technology adoption in terms of three mental structures: motives are inner mental reasons; technologies are tools that pertain to motives; and beliefs are associations between motives and/or technologies. Although the authors believe that agent-based artificial markets are destined to play an important role in the future study of innovation dynamics. But they have no further empirical study of the adoption process that leads to better theory should help artificial markets assume that role.

Based on the above subject of educational technology innovation diffusion analysis, this paper presents a dynamic diffusion model of ICT in education, as shown in Figure 2.

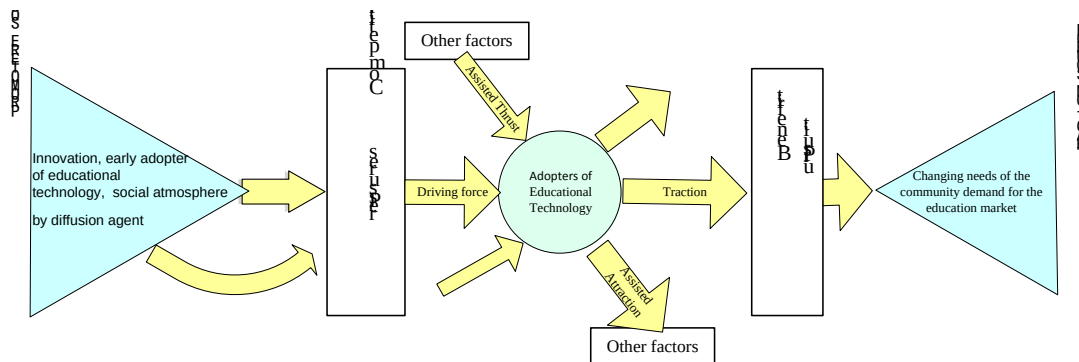


Figure 2. Framework of the Diffusion Power of ICT in Education

3.1 Driving Forces

Academic institutions, enterprises, governmental organizations, or even schools are likely to act as innovators or diffusion intermediary of educational technology, who are promoting the diffusion of educational technology in schools for their own purposes. For all primary and secondary schools, the external environment and atmosphere causes the increasing growth of competitive pressure among schools. They have to conform to the call and request of the government, enhance their competitiveness in cooperation with academic organizations and receive satisfactory service by bargaining with enterprises and so on. The above pressures are the driving forces.

3.2 Adopter' Benefits

Education is the equalizer and the driving force for social development, as well as bearing the responsibility of the transmission of human civilization. The dual responsibility requires education of a better development in the circumstances of effectively solving a variety of problems such as educational, social, cultural,

technological problems. Schools have to continuously improve external relations and internal structures according to the changes of the situation, promote the mutual development of core business and non-core businesses with the adoption of the innovations of educational technology, and achieve the enhancement of the scale and benefits of schools as well as the quality of teachers and students so as to meet the requirements of different aspects. Therefore, to “turn social demands into the demands of the education market” becomes the traction of the diffusion of educational technology in primary and secondary school.

Competitive pressures caused by external environment and early adopters, and the successful adoptions of income by adopters are the main adopters of educational technology. The interaction between the driving force and traction promotes the spread of educational technology innovations.

4. IMPROVING THE DIFFUSION POWER OF EDUCATIONAL TECHNOLOGY

Technology use is contextual and tends to follow, often invisible, ground rules. Within the situational context of education organization the rules and sanctions regarding technology use become increasingly complex. From the perspective of the status quo and reality of diffusion power, there is an enough strong external driving force in the development of educational technology in China, but the main barrier lies in the weakness of internal traction. This paper advises on how to improve the internal power as follows:

4.1 Adopters with the Positive External Guidance

In the process of the national vigorous promotion, the nonfeasance mentality in the educational industry is undesirable. On the one hand, the application of educational technology needs external active promotion and effective support, but the real effects of the application of educational technology need strong internal requirements and active changes. It is the key of the schools to achieve the improvement of educational quality with the recognition of the government, the society, parents and students. If the schools intend to develop highly correlated teaching and learning and improve internal structure and external relations, the positive changes are the fundament of improving the internal development power of schools. The available idea of enhancing internal power may be building the schools as learning organizations.

4.2 Cooperation of Different Driving Forces

In many cases, schools lack available institutional strategies for ICT. Interesting experimentation does not generally lead to successful dissemination and adoption on a wider scale. In many cases, the push for a substantial use of ICT in school programs has come from new educational markets, life-long learning or international education in particular. Inter-institutional and inter-sectoral collaboration between schools and companies are characteristics of many successful ICT initiatives, although they do not generally continue into sustainable implementation in the individual school. (Marijk v. d. W., et al., 1999)

The trend of plenty of cooperation between IT companies and academic organizations makes up for many weaknesses in the promotion of the state to a certain extent. Academic organizations start to cooperate with IT companies or assist the government to promote various projects instead of independently operating pilot projects on the application of educational technology previously, which has become more and more difficult. Recently, the academic-related core parts of most projects rely on some academic organizations and experts, and those projects also become the important object and the main battlefield of the research of academic organizations. At present, the problems in need of urgent

solutions, in reality, are how the governmental organizations, IT companies and academic organizations cooperate with each other and how to improve the application effects of educational technology by selecting appropriate promotional modes and contents, especially how the projects promoted by the government introduce some new mechanisms to ensure the best effects.

4.3 Strengthen In-depth Interactions between Academic Organizations and Schools

The effects of the application of educational technology cannot be simply decided by simple adoption. The effects of the application of educational technology are hierarchal. The costs and values vary at different levels. The level of application is enhanced with the promotion of academic organizations. The most important reasons that cause the obstacles in the application are the lack of detailed analysis of the application in deep levels and the lack of the idea of core value in application. The key to the effects of educational technology is to achieve the transfer and integration of technology.

Academic organizations can give suggestions on realizing the effects of the application of educational technology and give relatively better guidance to educational organizations. Therefore, in the diffusion process, we should vigorously promote the cooperation between academic organizations and schools, which can overcome the tendency of blindness and simplification of the governments or IT companies in the process of promotion.

5. Acknowledgements

We would like to thank all the people who participate in the research project of *New development of ICT in Education in Global Context* granted by Intel®.

6. References

- Eveland, J. D.(1979). Issues in using the concept of adoption of innovations. *Journal of Technology Transfer*, vol. 4, pp. 1-13.
- Holloway, R. E. (1997). Diffusion and adoption of educational technology: A critique of research design. In D. H. Jonassen. (Ed.). *Handbook of Research for Educational Communications and Technology*, pp 1107-1133. New York, NY: Simon & Schuster Macmillan.
- Leithwood, K., Louise, K. S., Anderson, S. & Wahlstrom, K. (2004). *How Leadership Influences Student Learning*. Minneapolis: University of Minnesota, Centre for Applied Research and Educational Improvement.
- Marijk van der Wende, Eric Beerkens(1999).An International Orientation on Institutional Strategies and Governmental Policies for the Use of ICT in Higher Education.*Interactive Learning Environments*, Vol. 7, Iss. 2-3.
- Martin Carnoy (2004).ICT in Education: Possibilities and Challenges. Retrieved from: <http://www.uoc.edu/inaugural04/dt/eng/carnoy1004.pdf>
- Mir Afzal Tajik(2008). External change agents in developed and developing countries. *Improving Schools*, vol. 11, no. 3, pp. 251-271
- Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). New York: Free Press.
- Xudong Zheng (2005), *Leading the Followers: On Donald Ely's Academic Thoughts of Educational Technology*, *e-Education Research*, no. 4, pp. 7-11.