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A DIALOGIC FRAMEWORK FOR ASSESSING COLLECTIVE CREATIVITY IN COMPUTER-SUPPORTED COLLABORATIVE PROBLEM-SOLVING TASKS

JENNIFER PEI-LING TAN *

National Institute of Education, Singapore
jen.tan@nie.edu.sg

IMELDA SANTOS CALEON

National Institute of Education, Singapore
imelda.caleon@nie.edu.sg

CHRISTIN REKHA JONATHAN

National Institute of Education, Singapore
christin.jonathan@nie.edu.sg

ELIZABETH KOH

National Institute of Education, Singapore
elizabeth.koh@nie.edu.sg

Creativity and collaboration are increasingly recognised as 21st century skills that schools should foster in learners. To understand how groups, organisations and communities innovate over time, these competencies need to be more effectively cultivated and assessed in individuals and groups. Assessing these competencies, however, has proven challenging, especially in K-12 learning contexts. In the field of CSCL, where the pedagogical premise is that knowledge and competencies are fostered through social interactions and dialogic negotiations, contemporary research has pointed to the affordances of a dialogue-based approach to assessing various learning processes and outcomes. While numerous dialogic frameworks now exist for assessing students' collaborative knowledge building and problem-solving skills, few frameworks connect these assessments to creative competencies. In this paper we propose a dialogic framework for theorising, measuring and fostering students' collective creativity in the context of computer-based collaborative problem-solving formative assessment tasks. We conceptualise collective creativity as encompassing a suite of metacognitive, cognitive and socio-communicative competencies, manifest in the interactions of student teams in their problem-solving process. We present the components of our framework and its operationalization through a content-analytic coding scheme. We then apply the proposed framework to a subset of students' dialogic interactions generated on a computer-based collaborative problem-solving formative assessment task in order to investigate the framework's potential affordances and to assess issues of reliability and validity. Results indicate favourable inter-coder reliability, and identify statistically significant differences in the dialogic features and patterns of successful and unsuccessful collaborative problem-solving student dyads. We conclude by discussing the limitations and the applicability of the framework as an effective way of profiling and scaffolding learning in online collaborative and creative problem-solving contexts.

Keywords: Creativity; collaborative problem-solving; 21st century competencies; formative assessment; content analysis; dialogic learning.

1. Introduction

To thrive in the social and professional landscapes of our contemporary knowledge-based economies, students need to learn to work with rapid change and in multiple communities and teams. While these competencies have always played important roles in the history of human progress, they have been traditionally viewed as resources largely available to, and developed in socially and economically elite groups in society (Bernstein, 2000). But these skills are no longer mere 'expressive affordances'. In contemporary highly-networked, technology-mediated knowledge economies, characterised by complexity and rapid change, creativity and collaborative problem-solving are more central to productive participation in local, global and virtual societies. Studying creativity in collaborative problem-solving is a challenging but increasingly vital endeavour for understanding how groups, organisations and communities innovate and progress over time (Wang, Farooq, & Carroll, 2010). The question of how these competencies can be more effectively cultivated and assessed in learners—at the individual level and also importantly as produced through social interactions at a collective level—presents a major global education challenge today. As pointed out by researchers specialising in educational assessment and 21st century skills (Kyllonen, 2012; Voogt & Roblin, 2012), the field currently suffers from a scarcity of viable and robust assessment tools for these competencies, especially in K-12 learning contexts. Developing theoretically-sound and evidence-based insights that address this global education challenge serves as the starting point of this paper.

We aim to contribute to this knowledge gap by proposing a dialogic framework for characterising, measuring and fostering students' *collective creativity* (CC) in the context of computer-based collaborative problem-solving (CPS) formative assessment tasks. Our emphasis on CC stems from recent scholarly calls in the field to move beyond traditional measurements of creativity as an individual mental property toward a focus on the collective and collaborative aspects of creativity—that is, its social and interactional dimensions (Miell & Littleton, 2004; Sannino & Ellis, 2013). To do so, we draw from a multidisciplinary body of work including creativity and computer-supported collaborative learning research, in particular, recent studies that relate CC efficacy and group micro-creativity with online CPS success (Cheng & Yang, 2011; Chiu, 2008; Wang et al., 2010), as well as theories of dialogic learning, content and interaction analyses.

In the sections that follow, we present our CC dialogic framework and coding scheme after a critical synthesis of pertinent research that informed our conceptualisation of CC as encompassing a suite of metacognitive, cognitive and socio-communicative skills, manifest in the talk-in-interaction (Hutchby & Wooffitt, 2008) of student teams throughout their CPS process. We then apply this framework to the analysis of students' CC competencies in one CPS formative assessment task designed and administered by the international Assessment and Teaching of 21st Century Skills (ATC21S) research programme during its Singapore school trials phase in 2012. Specifically, we use a subset of student log file data to demonstrate statistically how features and patterns of dialogic interactions differ between student dyads that were successful and unsuccessful in their joint problem-solving efforts. In doing so, we establish the reliability and validity of our framework and point to its potential affordances for more meaningful formative assessment and cultivation of students' CC and CPS competencies, particularly in CSCL contexts.

2. Conceptualising Collective Creativity in CPS Tasks

We begin our discussion by looking at current theorizations of creativity and its relationship with collaborative problem-solving to articulate our conceptualisation and operationalization of collective creativity in CPS contexts using a dialogic approach.

2.1. *Current theorizations of creativity*

While the first tide of systematic creativity research appears in the 1950s, a definitive theory on creativity has yet to emerge from the substantial body of research and literature on this topic. More recently, however, there has been some convergence on the idea that creativity means the ability to produce work which is novel, high in quality, and appropriate (Beghetto & Kaufman, 2007). This implies that creativity must involve novelty and unconventionality, but a parallel upshot is that the creative product is considered appropriate, useful or endorsed by experts according to relevant disciplinary standards or norms – a "good new idea" rather than just "a new idea". This definition foregrounds contemporary understandings of the nature of creativity as requiring a necessary balance point between divergence and conformity (Klausen, 2010). This stands in contrast to the view of creativity as encompassing only divergent thinking, in turn made popular by Torrance's early work that focussed on an individual's creative potential in terms of cognitive fluency, originality and elaboration. While these remain essential components of creativity, a more contemporary view is that creativity is a generative process that involves both divergent and convergent knowledge production (McWilliam, 2008; McWilliam, Tan, & Dawson, 2010).

Also relevant is the move away from non-malleable, traits-based talent or giftedness, towards more process-oriented and situational theories of creativity. For example, Sternberg and Lubart (2001) argue that a balance of attributes and resources—intellectual ability, knowledge, thinking styles, personality, motivation and importantly environmental enablers— is necessary to produce creativity. Similarly Amabile's (1996) componential theory of creativity and Csikszentmihalyi's (1996) systems theory of creativity accentuate the contextual and interactional aspects of person, domain, and field (disciplinary experts or gatekeepers) that together enable creative processes and products. These approaches posit that a certain degree of knowledge in a field is needed to generate a creative product or novel solution, but also that it is possible for too much knowledge to result in an entrenched and close-minded perspective. This phenomenon is otherwise referred to as functional fixedness (Mayer, 1992), which has been found to hinder solving new problems in new ways (Law, 2007).

These process-oriented theories of creativity are particularly relevant to K-12 teaching and learning. This is because they foreground the creative processes embedded in knowledge construction and the development of new understandings as experienced on a daily basis, moment-to-moment, by young students who have yet to "produce anything original or useful" in a socially transformative sense (Craft, 2005; Nicholls, 1972, p.717). In other words, creativity is premised on a developmental perspective and seen as a malleable and teachable competency that comprises a continuum ranging from a learner's novel and personally meaningful 'mini-c' interpretive construction of new knowledge and meaning, to 'Big-C' creativity of the sort displayed by historical greats such as Einstein, Beethoven, Picasso, Zhang Heng, Li Bai and others who effectively transformed their field (Beghetto & Kaufman, 2007; Kozbelt, Beghetto, & Runco, 2010; Yue & Rudowicz, 2002). This does not imply that all learning constitutes creativity, but rather, that the interpretive, constructive and transformative processes that underpin deep, expansive learning in its social and interactional forms constitute creative endeavours (Engeström & Sannino, 2010). It is this creative engagement and its key underpinning cognitive and social processes, as required of and experienced by learners on highly-challenging, ill-structured collaborative problem-solving tasks that constitutes our study's focus of inquiry.

A further process-oriented creativity framework informing our study is Cropley and Cropley's (2008) extended phase model of creativity. This model builds on earlier, pioneering works in creativity and problem-solving (Osborn, 1963) to conceptualise creativity as constituting seven distinct phases: preparation, activation, cogitation, illumination, verification, communication, and validation. These 'creative process' phases occur in a dynamic, iterative fashion, each of which can culminate in different key outcomes (e.g. radically new or adaptive), and are associated with or facilitated by a range of (i) cognitive and social processes (e.g. divergent/convergent thinking), (ii) motivational and personality properties (e.g. intrinsic/extrinsic reward; openness/compulsiveness), and (iii) environmental factors (e.g. tolerance of errors/demands for accuracy). This model turns the primary focus away from creative products toward creative potential and processes. This shift is important for schools because it shifts traditional narrow understandings of creativity as primarily situated within the individual and in the creative arts domains, toward a more holistic understanding of creative competencies and processes as essential to higher-order thinking, reasoning and problem-solving across and beyond the curriculum areas (Runco, 2008). It can serve as a template for designing a detailed and differentiated analysis of learning, teaching and assessment program and activities, which could be carried out across different age levels and disciplines.

The above discussion sets out the theoretical premise informing our conceptualisation of creativity as a developmental expertise underpinned by key cognitive and social processes embedded in deep learning experiences. We now turn to examine the link between creativity and problem-solving more closely, and to justify the importance of pushing beyond individualized creativity to study collective creativity, particularly in computer-supported CPS and learning contexts.

2.2. *Creativity and problem-solving*

The association between creativity and problem-solving has long been theorized and established in empirical research (Treffinger & Isaksen, 2005). This association has taken on different forms. Some researchers ascribe a relatively broad definition to critical thinking, such as reflective, unconventional, self-regulated, constructive, interactive, creative and problem-oriented. Creativity and problem-solving are thus subsumed under critical thinking. Others have posited problem-solving as an overarching concept that is underpinned by, and integral to creative thinking, critical thinking and reasoning skills (e.g. Law, 2007; Sternberg & Lubart, 2001).

While this association may take on different forms, it is generally acknowledged that creative competencies come to the fore primarily in problem-solving tasks that are ill-defined and ill-structured, rather than routine in nature. In ill-structured problems, information required to solve the problem is not entirely contained in the problem statement, steps and solution pathways are not clearly discernible, and therefore, the consideration of multiple ideas and opposing views are often necessary to task success. As highlighted by Saye and Brush (2002), ill-structured problems are often controversial and evoke dialectical aspects of creative reasoning, where the learner must engage in productive discourse to engage with others deeply in constructing knowledge and solutions. Ferreira and Lacerda dos Santos (2009) defined this as a move beyond sophisticated reasoning to dialectical creative reasoning that (i) generates new ideas, (ii) recognises alternative perspectives, (iii) evaluates the quality of evidence and reasoning used to support each perspective, and ultimately (iv) decides on a single/range of optimal solutions. Ill-structured CPS therefore involves a creative process that requires a combination of metacognitive skills (to iteratively strategize or plan and then evaluate the epistemic nature of problem-solving moves or solutions), as well as cognitive, social and communicative skills (Cropley & Cropley, 2008; Jonassen, 1997; Larkin, 2009). Put simply, ill-structured problem-solving is directly correlated with creative thinking in the real world, as they both require developing cogent arguments to support divergent thinking and reflective judgment (Jonassen, 1997; Ferreira & Lacerda dos Santos, 2009). This is especially so if the problem-solving task is collaborative in nature.

2.3. *Collective creativity in CPS contexts*

The current age of networked technologies increasingly requires teams with diverse skills and knowledge to collaboratively solve complex problems and create innovation. Past research on creativity, however, has focused substantially on individual-level mental property and outcome, rather than its shared production and materialisation in a social milieu (Miell & Littleton, 2004; Sannino & Ellis, 2013). Studying creativity in collaborative work is acknowledged as a highly challenging, but increasingly vital endeavour for understanding how groups and societies innovate and progress over time. In response, more recent creativity research has moved beyond individual creativity to study the social and interactional dimensions of collective creativity, at the level of dyads, groups, organisations and communities, and particularly in collaborative problem-solving and learning contexts (Chiu, 2008; Mamykina, Candy, & Edmonds, 2002; Sannino & Ellis, 2013). These studies, however, have been largely undertaken in organizational and adult learning contexts. Despite its acknowledged importance, the study of collaborative creativity among students in K-12 learning contexts, both online and offline, remains sparse.

From among the few studies undertaken in school settings Chiu (2008) is directly relevant: Group micro-creativity, operationalised as the number of new ideas manifested in high school students' collaborative argumentation discourse in an algebra unit, was found to be positively associated with collaborative problem-solving success. In addition, group micro-creativity was found to be positively associated with 'polite', rather than 'rude' evaluative statements, and with 'mutual grounding' through the use of questions and responses, rather than the use of 'instructive commands'. The term 'micro-creativity' was used as the study focused primarily on one element of creativity, the divergent production of new ideas. Chiu acknowledged the need to extend this line of inquiry to encompass a more holistic conceptualisation and operationalization of creative behaviour in group problem-solving contexts. A second directly relevant study, Cheng and Yang (2011), examined university students' levels of collective creative efficacy (CCE), conceptualised as the shared belief in the team's ability to collectively engage in a creative process to co-generate new and useful outcomes (in this case, novel software process improvement ideas). CCE was found to be positively correlated with better performance on selected tasks. The authors, however, recognised the limitation of focusing only on a limited component of creativity, that is, creative self-belief or potential. As did Chiu, they urged future studies to examine different interaction patterns pertinent to CCE and more comprehensive dimensions of collective creativity.

To address these specific knowledge gaps, we build on the preceding critical examination and synthesis of literature in the fields of creativity, problem-solving and computer-supported collaborative learning to conceptualise CC in CPS contexts as a multi-dimensional group expertise encompassing a suite of metacognitive, cognitive, social and communicative skills and sub-skill components, namely, reflexivity, divergent production, convergent production, and prosocial interaction. In sum, we articulate CC as the group's ability to collectively (i) plan, monitor and regulate shared objectives, strategies and solutions, (ii) generate and evaluate new ideas or solutions, and (iii) engage in prosocial communication in joint accomplishment of the task at hand. These CC skill dimensions and components are described further in Table 1.

Table 1. Collective creativity in CPS—Skill dimensions and components.

Skill Dimension	**Components**	**Description**
Meta-cognitive	Reflexivity (RF)	Group's ability to collectively self-examine, reflect on and repurpose group objectives, strategies, processes and solutions.
Cognitive	Divergent production (DP)	Group's ability to generate a variety of ideas, options, alternatives, methods to address the problem at hand.
	Convergent production (CP)	Group's ability to evaluate and narrow diverse opinions into one by reaching consensus on the best idea or integrating solutions.
Socio-communicative	Prosocial interaction (PI)	Group's ability to engage in reciprocal and productive (rather than negative) communicative interactions that enable (rather than hinder) the preceding cognitive and metacognitive processes.

3. Operationalising Collective Creativity: A Dialogic Framework and Coding Scheme

The various skill dimensions and components presented in Table 1 have been assessed and measured in a number of ways, including self-report questionnaires, others' ratings, situational judgment tests and performance tests (detailed in Kyllonen, 2012). In more recent years, however, with the proliferation of socio-cultural understandings of learning, particularly in the field of CSCL, the types and quality of peer collaborative discourse and interactions have been increasingly recruited as both indicators and predictors of productive cognitive, social and motivational learning processes and outcomes (e.g. Cho, Lee, & Jonassen, 2011; Tan, So, & Chai, 2011; Wegerif, 2010; Weinberger & Fischer, 2006).

In brief, these various theoretical and empirical studies are premised on a Vygotskian socio-cultural and dialogic perspective of learning, which sees knowledge as not only possessed individually but shared amongst members of communities who jointly construct shared learnings and understandings through dialogue and interactions. Vygotsky (1978) described language as both a cultural and psychological tool, where *intermental* (social, interactional) activity forges some of the most important *intramental* (individual) cognitive capabilities. Creation of meaning and knowledge is thus both an interpersonal and intrapersonal process, with ways of thinking embedded in ways of using language. Seen from this perspective, cognitive development is achieved through collective dialogue and meaningful interactions among fellow learners and significant others such as teachers. Cognitive processes are entwined with social and cultural practices: "talk and social interaction are not just the means by which people learn to think, but also how they engage in thinking—discourse is cognition is discourse—one is unimaginable without the other" (Resnick, Pontecorvo, & Säljö, 1997, p.2).

It is through this theoretical lens that we frame our working conceptualisation of CC in CPS tasks as being enacted through a process of discursive peer interactions where multiple ideas and perspectives are shared and considered, and where knowledge, meanings and solutions are generated, negotiated and re-negotiated. That is, the CC skills and components we take to be manifest and observable in the talk-in-interaction of student teams throughout their CPS process.

To this end, we developed a CC dialogic framework and content-analytic coding scheme that operationalized the CC skills and components in terms of 20 distinct dialogic indicators or talk-in-interaction coding categories. These are detailed in Table 2 (metacognitive dimension), Table 3 (cognitive dimension), and Table 4 (socio-communicative dimension). Examples for each of these dialogic coding categories, drawn from our analytic sample of student dyads' synchronous chat log data produced on a CPS task, are presented in Appendix A.

Having operationalized CC through the content-analytic framework and coding scheme detailed above (with examples for each coding category shown in Appendix A), we now report our initial efforts to empirically investigate its potential affordances and to assess issues of reliability and validity.

4. Empirical Validation of the CC Dialogic Framework and Coding Scheme

We empirically validated the proposed CC framework and coding scheme by applying it to a set of interactional log file data generated by students as they engaged in a CPS task designed and trialled by ATC21S in Singapore. We coded the content of students' synchronous chat logs produced on task and examined the extent to which the CC dialogic patterns and features differed between successful and unsuccessful problem-solving student teams. Through this process, inter-coder reliability and construct validity were established. Our approach and results are described in the following sub-sections.

4.1. *The ATC21S CPS Formative Assessment Task*

The ATC21S research program was established in 2009 with the core objective of developing new computer-based assessment tasks to evaluate and foster 21C skills in learners. This multi-stakeholder endeavour commenced with seed funding from four founding countries (Singapore, Australia, Finland and US) and three industry partners (Cisco, Intel and Microsoft), and is coordinated by the Assessment and Research Centre (ARC) at the University of Melbourne. It now involves an international community comprising more than 200 researchers, developers, education specialists, policymakers and practitioners. To date, ATC21S has developed a number of computer-based CPS formative assessment tasks that were piloted and trialled in schools across multiple countries in 2012, with country-specific analyses and reports recently completed and shared with country representatives (ATC21S, 2014).

In these school trials, which lasted approximately 90 minutes per session, students were required to work on individual computers with a randomly-paired anonymous peer (i.e. in student dyads) to solve a series of ill-defined CPS tasks together, using an online synchronous chat tool as their only form of communication. Despite some design

Table 2. CC dialogic framework and coding scheme: Metacognitive dimension.

Reflexive Dialogue (RFD): *Dialogue moves demonstrating the group's ability to collectively self-examine, reflect on and repurpose group objectives, strategies, processes and solutions*	
Coding Categories	**Descriptions**
RFD1 Monitoring	Dialogue moves that indicate evaluative awareness or reflective judgments of self and partner's progress in, or experience of, the problem-solving process
RFD2 Planning	Dialogue moves that indicate planning together for future activity in the problem-solving process, e.g. sequencing of activities or choice of strategies
RFD3 Regulation	Dialogue moves that indicate regulation processes directed to influence the partner's cognition, motivation or action

Table 3. CC dialogic framework and coding scheme: Cognitive dimension.

Divergent Production Dialogue (DPD) *Group's ability to generate a variety of ideas, options, alternatives, methods to address the problem at hand*	
Coding Categories	**Descriptions**
DPD1 Solution Generation-Epistemic	Dialogue moves that indicate new ideas and possible solutions that are rules-based or criteria-related in nature, or concern general parameters for decision-making
DPD2 Solution Generation-Concrete	Dialogue moves that indicate new ideas and possible solutions that are concrete or specific in nature
DPD3 Solution Generation-Elaboration	Dialogue moves that provide further information, explanation or justification on a previously stated idea and/or make associations across different ideas
DPD4 Premature closure *(anti-divergent)*	Dialogue moves that indicate the desire to bail out or not wanting to think further about possible solutions
Convergent Production Dialogue (CPD) *Dialogue moves demonstrating the group's ability to evaluate and narrow diverse opinions into one by reaching consensus on the best idea or integrating solutions*	
CPD1 Problem Defining/ Establishing	Dialogue moves that describe the problem and seek to establish a joint problem space (e.g. describing one's screen view to the partner in order to establish if both have the same information)
CPD2 Problem Analysis	Dialogue moves that attempt to define, ascertain, make sense of the causes or rules behind the problem
CPD3 Solution Evaluation-Acquiescence	Dialogue moves that indicate simple agreement with criteria development or solution suggestion statements
CPD4 Solution Evaluation-Checking	Dialogue moves that indicate checking or evaluating criteria development or solution suggestion statements (e.g. asking for confirmation from partner of the suggested solution or decision)
CPD5 Solution Evaluation-Critique	Dialogue moves that dispute, doubt or probe criteria development or solution suggestion statements
CPD6 Solution Evaluation-Justification	Dialogue moves that evaluate alternatives to the proposed criteria development or solution suggestion statements, and give reasons, explicit or implicit, for the evaluations

Table 4. CC dialogic framework and coding scheme: Socio-communicative dimension.

Prosocial Interaction Dialogue (PID)	
Dialogue moves demonstrating the group's ability to engage in reciprocal and productive communicative interactions, including mutual grounding, that enable (rather than hinder) the preceding metacognitive and cognitive processes	
Coding Categories	**Descriptions**
PID1 Mutual Grounding-Questioning	Dialogue moves that represent attempts to establish shared understandings with partner through the use of questions (e.g. clarifying what is meant by the preceding statement; whether it be related to the problem task, proposed solution or strategy/future activity)
PID2 Mutual Grounding-Responding	Dialogue moves that represent an 'adjacency pair' response to the preceding question statement, with the objective of establishing shared understandings with partner (e.g. providing answer or information to question)
PID3 Affective	Dialogue moves that express positive affect or emotion. Includes repetitious punctuation, conspicuous capitalization, emoticons, humor, teasing, thanks, apologies, empathy
PID4 Cohesive-Task	Dialogue moves that indicate team-directed positive affect that is related to the task at hand. Includes consulting and valuing partner's perspective and contribution (e.g. referencing others, acknowledgment, polite markers, encouragement, addressing the group using we, us, our)
PID5 Cohesive-Playful	Dialogue moves that indicate team-directed positive affect, but is off-task and playful in nature. Includes off-topic jokes and statements that serve a purely social function: greetings, salutations, phatics, closures (rather than actually conveying information)
PID6 Disaffective *(anti-social)*	Dialogue moves that express negative affect or emotion, including disengagement from task
PID7 Uncohesive *(anti-social)*	Dialogue moves that indicate team-directed negative affect (e.g. disruptive, rude, messages that indicate lack of respect, blaming or invalidating)

variations, the ATC21S CPS tasks could be categorized as ill-structured rather than well-structured problem tasks, because the rules and goal states are often not explicitly defined and not easily resolved with any degree of certainty. The raw log file data generated on these CPS tasks during the school trials were made available to the respective country representatives for further analysis. This constituted the data source for our study.

The CPS task of focus in this paper is 'Small Pyramids'. In this task, players have to utilize their problem-solving abilities and understanding of number series to figure out the rules of a number pyramid. The task begins with each dyad exploring a three-tiered pyramid in order to determine the rules of the pyramid, i.e. how the number they key into the red box at the bottom left of the pyramid is associated with the number that appears in the black box at the top of the pyramid (ATC21S, 2012). Each player has access to a different piece of information and must work collaboratively to solve the problem (e.g. only player A can key numbers into the red box while only player B can see the number in the black box). 'Small Pyramids' comprises three sub-tasks that can and have been scored by ATC21S in terms of whether students achieved accurate solutions: (i) sub-task

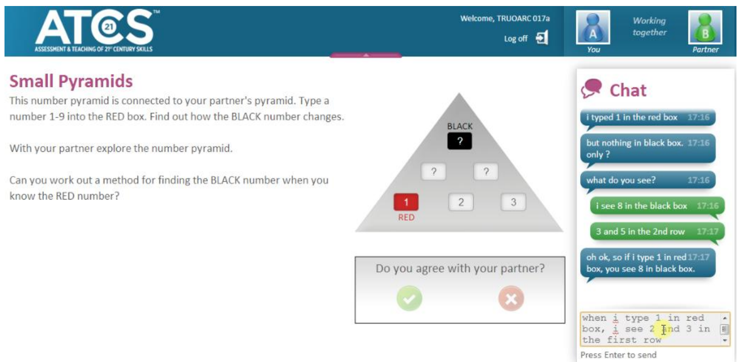

Figure 1. Screenshot of Small Pyramids (Sub-Task 1): Player A view.

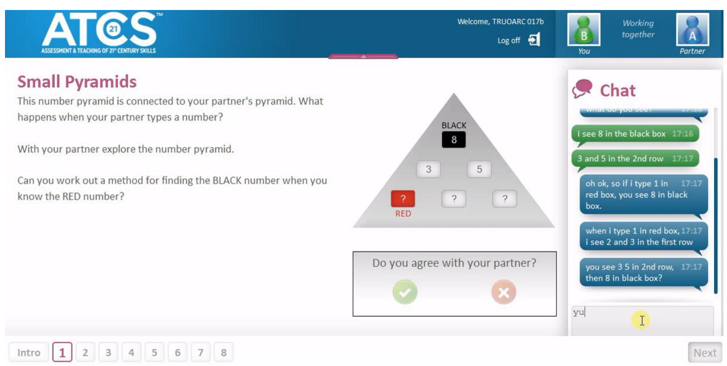

Figure 2. Screenshot of Small Pyramids (Sub-Task 1): Player B view.

1 requires players to find the number in the black box when the red box is '6', which player B can see once player A types '6' in the red box; (ii) sub-task 2 requires them to find the number in the black box when the red box is '20', which entails deriving the answer from the rules of the pyramid as they can only type single-digit numbers into the red box; and (iii) in sub-task 3, both players can see the number in the red box of a two-tiered pyramid and have to use the same rules as before to find the number in the black box.

4.2. *Selection of analytic sample*

A total of 79 Secondary One (Year 7) and 62 Secondary Three (Year 9) student dyadic teams completed the task during the ATC21S Singapore school trials. Drawing on the

ATC21S indicators provided in their scored data file of whether each individual participating student achieved accurate solutions on each of the three sub-tasks described in the preceding section, we operationalized the measure of team performance on task as the composite of accuracy and consensus, that is, the team jointly achieving accurate solutions to the CPS sub-tasks. Student dyads who jointly achieved accurate answers to all three sub-tasks received a CPS task performance score of three, and were deemed to be successful student dyads (N=45, comprising 24 Secondary One and 21 Secondary Three dyadic teams). Student dyads who did not jointly achieve accurate answers to all the three sub-tasks, even though one of the students in the dyad could have achieved accurate sub-task solutions at an individual level, received a score of 0, and were deemed to be unsuccessful CPS teams (N=38, comprising 25 Secondary One and 13 Secondary Three dyadic teams). Student dyads who jointly achieved accurate solutions for one or two sub-tasks achieved a team CPS task performance score of 1 or 2 respectively, and were correspondingly deemed to be slightly or moderately successful student dyads.

To form our analytic sample, we randomly selected 30 student dyads, with an equal number of successful and unsuccessful dyads (3-scorers and 0-scorers respectively). Each group comprised a comparable number of Secondary One and Secondary Three student dyads, which were mostly of mixed gender composition. The successful group comprised 13 mixed gender dyads, 1 all-female dyad, and 1 all-male dyad, while the unsuccessful group comprised 10 mixed gender dyads, 4 all-female dyads, and 1 all-male dyad.

4.3. *Coding*

The content of these student dyads' talk-in-interaction message stream generated via the synchronous chat tool throughout their CPS process on the Small Pyramids task were analysed and categorised using the CC dialogic framework and coding scheme set out in Tables 2, 3, 4 and Appendix A. Each dialogic category was coded as a binary variable (1 if present, otherwise 0). As recommended by Poole, Ven, Dooley, and Holmes (2000), in order to describe processes in a reliable manner, content analysis of electronic dialogue messages or transcripts should involve segmenting the data stream into meaningful units, and using a theoretically-informed coding scheme to categorise these units.

For our purposes, each individual message was considered one meaningful unit as a general rule because most of the synchronous chat messages produced by the students on task were short and usually contained a single communicative function or intention (Strijbos, Martens, Prins, & Jochems, 2006). However, where a single message contained compound functions, it was segmented for analysis and coding. Following Chiu and Hsiao (2010), punctuation and connectives were used as indicative markers to segment compound messages if the utterances prior and subsequent to these markers were deemed to be meaningful. Also, incomplete messages (i.e. statements that stop abruptly and/or where the intended meaning or communicative functions are evidently unfinished) that were completed by successive messages were coded as a consolidated unit. The transcripts of the talk-interaction of the 30 student dyads were coded by two researchers independently.

4.4. *Inter-coder reliability*

We adopted a multi-method approach to assess inter-coder reliability across all the 20 CC dialogic categories by computing percentage joint agreement, Cohen's kappa (Cκ), and Krippendorff's alpha (Kα) formula for binary data with two observers and no missing data (Krippendorff, 2013). Of these three, Kα has been regarded as the most stringent reliability statistic, with the additional strengths of being able to adapt to any level of measurement and number of observers, as well as address missing data in the analysis (Strijbos & Stahl, 2007). By accounting for expected disagreement occurring due to chance, Kα avoids overestimating inter-coder reliability (Lombard, Snyder-Duch, & Bracken, 2004). Furthermore, the use of canonical agreement matrices with each row representing a coder and each column a coding unit prevents loss of information, unlike simple agreement tables and contingency tables (Passonneau, 2006). We constructed 2 observers- by -2170 units (lines) reliability data matrices for each dialogic category then tabulated the coincidences within lines for all values (essentially, a tabulation of pairs of codes given by the two coders for each line) for each of the matrices. Kα -reliability was then computed using the following formula (where D_o is the observed disagreement and D_e the disagreement expected by chance): $\alpha = 1 - D_o / D_e$ (Krippendorff, 2013). Following Strijbos and Stahl (2007), we employed the Cκ and Kα reliability criteria widely-used in content analysis, where (i) Cκ < 0.2 is poor, 0.2 to 0.39 is acceptable, 0.4 to 0.59 is moderate, 0.6 to 0.79 is good, and 0.8 and above is very good; and (ii) Kα < 0.45 is low, 0.45 to 0.59 is moderate, and 0.60 and above is high.

4.5. *Construct validity*

We adopted two approaches to assess the construct validity of the analytic framework and coding scheme. First, we asked a panel of experts to evaluate the content validity of the framework and coding scheme. Second, we used chi-square analysis to determine the association of the frequencies for each CC dialogic dimension of successful and unsuccessful CPS teams. Along with providing empirical insights into whether CC dialogic patterns and features differ statistically between successful and unsuccessful CPS teams, such a comparative analysis can also serve as an indicator of our CC dialogic framework and coding scheme's predictive validity (Messick, 1995).

Following from the theoretical underpinnings of our CC dialogic framework and coding scheme discussed in the preceding sections, our postulation is that successful CPS teams are likely to engage *more frequently* in reflexive dialogue (i.e. monitoring, planning and regulation talk categories), pro-divergent dialogue (i.e. solution generation-epistemic, concrete and elaboration talk categories), convergent dialogue (i.e. problem establishing and analysis, solution evaluation: acquiescence, checking, critique and justification talk categories), and prosocial dialogue (mutual grounding question and response, affective, cohesive-task and social talk categories), while engaging *less frequently* in anti-divergent and anti-social dialogue (i.e. premature closure talk, disaffective and uncohesive talk).

5. Results and Discussion

5.1. *Reliability*

The application of the proposed framework and coding scheme on our data achieved (i) percentage joint agreement ranging from 89% to 99.7% across the 20 CC dialogic categories, (ii) moderate to very good Cκ reliability coefficients across all 20 categories (3 very good, 9 good, 8 moderate), and (iii) moderate to high Kα-reliability for all 20 categories (12 high, 8 moderate). These results, detailed in Table 5, indicate that the proposed CC dialogic framework and coding scheme offer promising inter-rater reliability for trained coders. This in turn provided us with greater confidence in the proposed framework's potential affordances for assessing CC competencies in successful and unsuccessful CPS student dyads. Having said that, there remains room for improvement in the inter-coder agreement, especially for the 8 coding categories that reported moderate Cκ and Kα-reliability coefficients. Work is currently underway to negotiate and resolve inter-coder differences on these categories, after which the refinement of the coding scheme and/or retraining of the coders will be conducted as necessary.

Table 5. Inter-coder reliability results.

CC Dialogic Categories	Joint Agreement Percentage	Cohen's Kappa	Kα Reliability Coefficient
RFD1 Monitoring	96.9%	0.58	0.58
RFD2 Planning	89.0%	0.59	0.59
RFD3 Regulation	95.6%	0.65	0.65
DPD1 Solution Generation-Epistemic	99.4%	0.72	0.72
DPD2 Solution Generation-Concrete	97.5%	0.82	0.82
DPD3 Solution Generation-Elaboration	99.6%	0.71	0.71
DPD4 Premature closure *(anti-DP)*	97.9%	0.48	0.48
CPD1 Problem Defining/Establishing	93.0%	0.76	0.76
CPD2 Problem Analysis	96.5%	0.66	0.66
CPD3 Solution Evaluation-Acquiescence	98.5%	0.71	0.71
CPD4 Solution Evaluation-Checking	99.6%	0.91	0.91
CPD5 Solution Evaluation-Critique	98.5%	0.54	0.54
CPD6 Solution Evaluation-Justification	99.7%	0.67	0.67
PID1 Mutual Grounding-Questioning	97.5%	0.80	0.80
PID2 Mutual Grounding-Responding	96.3%	0.70	0.70
PID3 Affective	91.7%	0.51	0.50
PID4 Cohesive-Task	91.8%	0.46	0.46
PID5 Cohesive-Playful	96.2%	0.65	0.65
PID6 Disaffective *(anti-PI)*	96.2%	0.50	0.50
PID7 Uncohesive *(anti-PI)*	98.2%	0.56	0.56

5.2. *Validity*

We found evidence upholding the construct validity of the coding scheme. The panel of experts indicated the good theoretical coverage and representativeness of the coding scheme. Results arising from the comparative chi-square analysis of dialogic features and patterns between successful and unsuccessful teams across all coding categories generally converged with our postulations set out in Section 3.5. These results are summarized in Table 6, and further illustrated in Figures 3, 4 and 5.

In accordance with our postulations, successful CPS teams as compared to their unsuccessful peers, demonstrated (i) higher occurrences of all 3 reflexive dialogue categories, in particular planning and regulation talk (Figure 3), (ii) higher occurrences of pro-divergent dialogue, especially solution generation talk (Figure 4), (iii) lower occurrences of anti-divergent dialogue, this is, premature closure talk (Figure 4), (iv) higher occurrences of all convergent dialogue categories, in particular problem defining and problem analysis talk (Figure 4), and (iv) higher occurrences in a number of prosocial dialogue categories, namely, mutual grounding, affective and cohesive-task talk (Figure 5). On the other hand, counter to our postulations, we found that successful CPS teams engaged less frequently in cohesive-playful talk (Figure 5), while reporting higher occurrences of negative affect—both individual-oriented (disaffective talk) and team-directed (uncohesive talk)—in their dialogic interactions on task relative to their unsuccessful counterparts (Figure 5).

These differences in dialogic patterns were found to be statistically significant for reflexive dialogue and convergent production dialogue at ($p<0.05$), and divergent dialogue and prosocial interaction dialogue ($p<0.001$). Taken together, these results provide empirical support for the predictive validity of the CC framework and coding scheme. There were also some surprising findings pertaining to 3 dialogic categories (cohesive-playful dialogue, disaffective dialogue, and uncohesive dialogue) that provide us with new insights into the relationship between CC and CPS in the context of computer-supported formative assessment tasks that could benefit from future research. These are discussed next.

Figures 3, 4 and 5 provide further visual representations of the frequency of occurrences of CC dialogic features and patterns between successful and unsuccessful CPS teams.

Table 6. CC dialogic patterns of successful and unsuccessful CPS teams.

	Successful Teams	**Unsuccessful Teams**	**Difference**	χ^2	***df***	***p***
	<a>	<b>	<a>-<b>			
CC Dialogic Categories	*Frequency of Coded Occurrences*					
Dimension: Reflexive Dialogue				8.06	3	*.045*
RFD1 Monitoring	48	33	15			
RFD2 Planning	258	146	112			
RFD3 Regulation	85	33	52			
Dimension: Divergent Production Dialogue				24.23	4	*<.001*
DPD1 Solution Generation-Epistemic	20	8	12			
DPD2 Solution Generation-Concrete	93	64	29			
DPD3 Solution Generation-Elaboration	27	8	19			
DPD4 Premature closure *(anti-DP)*	17	35	(18)			
Dimension: Convergent Production Dialogue				12.72	6	*.048*
CPD1 Problem Defining/ Establishing	242	123	119			
CPD2 Problem Analysis	75	36	39			
CPD3 Solution Evaluation-Acquiescence	47	18	29			
CPD4 Solution Evaluation-Checking	30	20	10			
CPD5 Solution Evaluation-Critique	23	21	2			
CPD6 Solution Evaluation-Justification	8	2	6			
Dimension: Prosocial Interaction Dialogue:				232.39	7	*<.001*
PID1 Mutual Grounding-Questioning	235	197	38			
PID2 Mutual Grounding-Responding	220	108	112			
PID3 Affective	71	59	12			
PID4 Cohesive-Task	197	138	59			
PID5 Cohesive-Playful	118	178	(60)			
PID6 Disaffective *(anti-PI)*	64	51	13			
PID7 Uncohesive *(anti-PI)*	34	16	18			

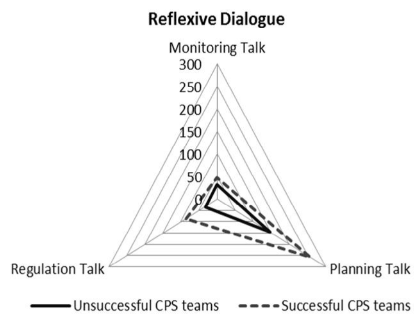

Figure 3. CC reflexive dialogue patterns of successful and unsuccessful CPS teams.

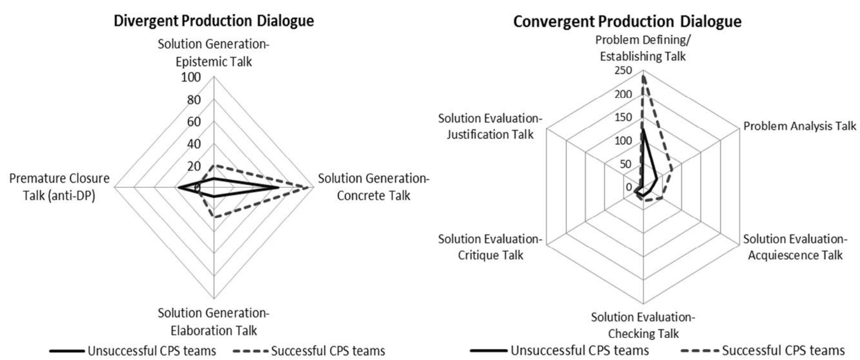

Figure 4. CC divergent and convergent dialogue patterns of successful and unsuccessful CPS teams.

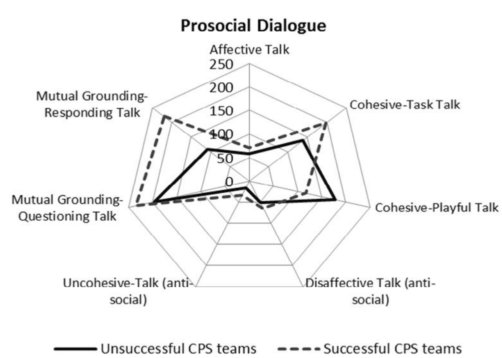

Figure 5. CC prosocial dialogue patterns of successful and unsuccessful CPS teams.

5.3. *General discussion*

To summarise, results suggest that our proposed dialogic framework and coding scheme constitute a reliable and valid approach for analysing students' collective creativity competencies on CPS tasks. Inter-coder reliability across all CC dialogic categories was found to be promising, ranging from moderate to very good. Statistically significant differences in the CC dialogic moves of successful and unsuccessful CPS student dyads largely resonated with our theoretically-informed postulations of the relationships between CC skill dimensions and components and CPS task performance. Findings indicate that successful CPS teams engaged *more frequently* in reflexive dialogue (planning, monitoring and regulation talk), pro-divergent dialogue (solution generation: epistemic, concrete and elaboration talk), convergent dialogue (problem defining and analysis talk; solution evaluation: acquiescence, checking, critique and justification talk), and task-related prosocial dialogue (mutual grounding, affective and cohesive-task talk). A closer analysis of the results highlighted three key distinctive characteristics of successful dyads' dialogic patterns across all the categories of CC dialogic moves.

First, successful dyads engaged *most frequently* in discursive interactions aimed at establishing mutual, shared understandings through (i) the planning and coordinating of problem-solving strategies, (ii) establishing a joint problem space, and (iii) reciprocal questioning and responding. These were closely followed by talk that fostered positive group affect or cohesiveness, both on-task and off-task, as well as statements that reflect generative thinking, that is, new idea or solution propositions that are concrete in nature.

Second, successful dyads demonstrated *highly proportionate occurrences* of the 'adjacency-pair' talk: mutual grounding-questioning and responding. This dialogic feature points to healthy levels of transactive reciprocity within these successful CPS dyads. This stands in sharp contrast to their unsuccessful peers, who were observed to have significantly lower occurrences (i.e. approximately half) of responding relative to questioning talk, the implication here being that unsuccessful student dyads were much less reciprocal or attentive towards their partners in their communicative interactions throughout the CPS process.

Third, successful dyads engaged in *significantly less* premature closure talk and off-task playful talk relative to their unsuccessful counterparts. Premature closure is a counter-productive form of talk that indicates the speakers' intentions to bail out or cease thinking about potential ideas and solutions to the problem task at hand. Our findings indicate that such dialogic moves directly constrain divergent production, which we have established earlier as an essential cognitive skill dimension of creativity. They are also negatively associated with CPS success.

In our study, cohesive-playful talk refers to dialogic moves that demonstrate team-directed positive affect, but as opposed to its task-oriented counterpart 'cohesive-task talk', these are non-task oriented and purely social and playful in nature. Extant literature presents mixed perspectives regarding this form of talk. In conventional CSCL content analysis studies, these are usually classified as off-task discourse that are either excluded from the analysis or generally considered to be counter-productive to task performance.

However, playful off-task talk has been more recently argued to be positively related to students' group-level creative learning processes and performance (Kangas, 2010; Wegerif, 2005). On one hand, our findings show that successful CPS teams do engage frequently in off-task playful dialogue, which points to the productive social utility of this form of talk. A critical point to note, however, is that successful teams engaged *less frequently* in off-task talk (albeit cohesive in nature) as compared to on-task cohesive talk, and this dialogic pattern was inverted for unsuccessful teams. That is, unsuccessful teams engaged in a higher proportion of cohesive talk that was non-task related, rather than task-related. This finding provides more nuanced empirical insights into the dual nature of off-task playful talk, in that it can both contribute positively to team cohesiveness and creativity, but when used disproportionately, can become counter-productive to CC and successful CPS task performance. On this note, further research into the nature and role of 'playful talk' in promoting creative and collaborative learning processes and outcomes in students may prove useful.

We were also surprised to find that successful CPS teams expressed more disaffection in their dialogic interactions on task, as compared to their unsuccessful peers. This is in view of disaffection being conventionally understood to be closely associated with a range of adverse socio-emotional, cognitive and behavioral outcomes, such as stress, anxiety, low subjective well-being, disengagement, poor workplace and learning performance (e.g. George & Brief, 1992; Lopes, Grewal, Kadis, Gall, & Salovey, 2006; Skinner, Furrer, Marchand, & Kindermann, 2008). Some recent research, however, on affect-cognition models employing dual-process theories has pointed to the benefits of negative affect, such as improved memory and judgmental accuracy, greater perseverance and reduced self-handicapping behaviors in tasks where success is uncertain (Forgas, 2013; Goldenberg & Forgas, 2012), and on a related note, enhanced critical thinking and creative problem-solving outcomes (Vosburg & Kaufmann, 1997; Walton, 2011). Empirical evidence, however, is limited and therefore, the relationship between affect and cognition remains arguably inconclusive. What is clear, however, is the need to push beyond simple binary formulations of positive and negative affect as inherently good or bad for learning, and furthering investigations into optimal permutations and contexts in which both forms of affectivity can be harnessed for transformative 21st century learning, both cognitive and social. In substantiation of this point, our seemingly counter-intuitive finding of successful CPS teams engaging in more disaffective dialogue would benefit from further investigations of CC dialogic patterns in a wider range of CPS tasks and contexts, and accounting for individual and team characteristics, such as gender and prior achievement, and their combinations in the analyses.

6. Implications and Limitations

The findings reported in this paper indicate several implications for the formative assessment and development of students' collaborative and creative problem-solving competencies in CSCL contexts. In light of the acknowledged need for more viable and robust formative assessment tools that can help promote students' acquisition of 21st century competencies in the K-12 education sector, we have set out a theoretically-informed and empirically-grounded dialogic framework and coding scheme for analysing students' CC competencies in CSCPS contexts. The learnings generated from our current investigation, although exploratory, can nevertheless potentially complement and enrich the current suite of national and international standardised and school-based assessments in the traditional disciplinary areas.

Going further, this CC dialogic framework complements the international ATC21S work in two ways. First, the CPS assessment framework and methodology employed by ATC21S, though innovative and comprehensive, have an acknowledged limitation in that the qualitative content of students' synchronous chat message streams are largely unaccounted for in their analysis and scoring of students' CPS proficiency levels (ATC21S, 2012). Rather, any analysis of the electronic dialogue generated on tasks involved the use of coarse indicators such as the number of questions as indicated by question marks, the existence of chat blocks prior to an action, and the like. In our analysis of the content of students' synchronous chat logs, however, we identified many occurrences where students' conveyed their intended meanings using lexical and morpho-syntactic choices that were highly simplified, colloquial and oftentimes incomplete (e.g. not predicating questions with the appropriate punctuation "what do you see now", "how to do"). These have in turn been observed to be common linguistic properties of short text messages (Rafi, 2008). Given that CPS is necessarily a social and interactional process, compounded by the fact that synchronous chat was the only form of communication tool afforded to students in the ATC21S CPS tasks, the quality of students' dialogue produced on tasks necessarily constitutes a valuable data corpus that needs to be adequately examined when assessing students' CPS skills.

Second, our dialogic approach allows for the generation of rich, multidimensional CC micro-profiles that can help students and their teachers reflect on and further develop their strengths and skills gaps across the suite of competencies that underlie collaborative and creative problem-solving in CSCL contexts. This stands in contrast to the more sequential 'lockstep' developmental progression approach adopted by ATC21S. To derive the CPS learning progression point for each student, ATC21S applied an automated scoring and calibration mechanism using Rasch's probabilistic statistical modelling to rate students' activity logs (but excluding the content of students' dialogic exchanges produced on tasks) along a three-point developmental scale (low, medium, high) across a suite of theorised CPS cognitive and social skills sub-dimensions. These are then aggregated to derive an individual score and statistically-estimated point on each of the cognitive and social developmental progression scales (Griffin, McGaw, & Care, 2012). While such an approach offers scoring efficiencies and ease of interpretability, it arguably provides a poor representation of the potentially diverse communicative resources and dynamic knowledge-building interactional processes drawn upon and experienced by students as they engage in collaborative and creative problem-solving endeavours (Kapur & Bielaczyc, 2012; Reimann & Kay, 2010; Tan & McWilliam, 2009). Contemporary empirical research stresses the importance of various forms of interactions as critical to the quality of learning outcomes, particularly in CSCL contexts (Dillenbourg & Traum, 2006; Strijbos, 2011; Prinsen, Volman, & Terwel, 2007a, 2007b). As such, our CC dialogic framework, which focuses the analysis on students' talk-in-interactions throughout their CPS processes, can help inform alternative analyses and representations of task performance in ways that make visible the collaborative discourse and interactional dynamics amongst students. This will in turn help students and teachers foster more productive peer dialogic interactions that can help promote deeper knowledge building and more effective collaboration and creativity in joint problem-solving practices.

There are, however, several limitations to our study that need to be highlighted. First, while we achieved high percentage joint agreement figures and good Cκ and Kα-reliability scores for more than half of the dialogic categories, there is room for improving the reliability on eight categories that reported moderate inter-coder reliability coefficients. Measures to review and resolve inter-coder differences on these categories are currently being undertaken. Findings pertaining to these categories should be interpreted with prudence and taken to be indicative rather than conclusive at this time. Second, although our CC dialogic framework and coding scheme identified statistically significant distinctions in the dialogic patterns and features of successful and unsuccessful CPS teams, these results are limited to one specific CPS task. Thus, the empirical insights reported in this paper are suggestive rather than definitive, and need to be further investigated across more CPS tasks to ascertain their generalizability. Lastly, the analyses reported here do not take into account individual and group level differences. On this note, researchers in collaborative learning have reported mixed findings with some studies showing that gender and prior academic achievement affect task performance (Ding, Kim, & Richardson, 2006; Prinsen et al., 2007b; Wentzel & Watkins, 2002). It would be useful for future studies to examine the extent to which such background variables may directly and/or indirectly influence students' CC competencies.

7. Concluding Remarks

This study demonstrates the potential affordances of our proposed dialogic framework as a reliable and valid approach for assessing students' collective creativity competencies in computer-supported collaborative problem-solving contexts. Having conceptualised and operationalized collective creativity as a suite of metacognitive, cognitive and socio-communicative skills and sub-skills that are manifest and observable in multiple categories of students' talk-in-interaction, we foregrounded statistically significant and conceptually interpretable distinctions in the dialogic interactions of successful and unsuccessful CPS teams. In light of these findings, we emphasise the value of a dialogue-based formative assessment approach that can make visible students' collaborative discourse and interactional dynamics on CSCL tasks. This can in turn provide students and teachers with more productive recourse in the challenging endeavour of fostering more effective collaboration and creativity in joint problem-solving practices. We are hopeful that the dialogic framework and coding scheme presented here can be part of a global effort that augments current understandings and designs of formative assessments for cultivating essential 21st century collaborative and creative problem-solving skills in young people.

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Appendix A. Examples of CC Dialogic Coding Scheme Categories

CC Dialogic Categories	Examples
Reflexive Dialogue	
RFD1 Monitoring	"I know what to do", "this is so hard", "OK GOT THE ANS!!", "I like your answer", "Confusing!", "we solved it"
RFD2 Planning	"Try the second row, 2 and 3?", "ok now I tell u what can I see", "so i clicked yes. then?", "I think we can move on"
RFD3 Regulation	"you finish already?", "hurry, we're lagging behind", "R U THERE?", "stop speaking in ML", "NOW JUST AGREEE BELOW", "oi!!!!!"
Divergent Production Dialogue	
DPD1 Solution Generation-Epistemic	"The 2nd row plus together is equal to the BLACK", "n*2+1", "bottom 2 ad together equals to the one above", "n=x+y"
DPD2 Solution Generation-Concrete	"Is it 17?", "I put 3", "try typing 4 I type 1", "84", "ok my ans is 27"
DPD3 Solution Generation-Elaboration	"you see arh, 13 and 15 add together is 28 right? then the bottom number, which is 6 + the middle numble should be 13?", "basically its like number bond (i forgot the name) and numbers in increasing order"
DPD4 Premature closure *(anti-DP)*	"you just type whatever you want.. good luck" "you just give me the answer la", "What's the answer? I lazy to think!", "B: What to do now??; A: anyhow do lor"
Convergent Production Dialogue	
CPD1 Problem Defining/ Establishing	"What can you see from your computer?", "I cnt see the 9", "okay i cant do anything to it", "you can see bottom 3?", "?; ??; that is the wat i have in the screen(?)", "12,5,7"
CPD2 Problem Analysis	"u know the bottom 3; I know the top 3", "bottom 2 ad together equals to the one above", "u are black I am red; Numbers can only be typed in the red box"
CPD3 Solution Evaluation-Acquiescence	[preceding solution statement by partner]…"ok!"; "okay okay 7"; "yeap", "okok", "done"
CPD4 Solution Evaluation-Checking	[preceding solution statement by partner, e.g. "*A: I thought its n+(n+1)*"]…"B: also can"; "type the exact same thing?", "you think so?", "Is it 17??"
CPD5 Solution Evaluation-Critique	[preceding solution statement by partner]…"can't la… doesn't make sense lorrhh"; "the number is too big"
CPD6 Solution Evaluation-Justification	"yours [is better]! I forgot the x", "no lah. Mine is clearer, you see arh… the difference between the red and yellow box is 2; so 8+10 is 18"
Prosocial Interaction Dialogue:	
PID1 Mutual Grounding-Questioning	"You mean the pyramid?" "You put 9?" "So click left or right one?", "sure?", "What happen?", "nothing?", "type numbers right?", "you know how to do?"
PID2 Mutual Grounding-Responding	[preceding question by partner A included for context]… "*A: can see?* B: nothing…", "*A: then what's on your screen?* B: a pyramid telliin me to make my own puzzle", "*A: write liao?* B: write liao"
PID3 Affective	"VERY GOOD", "yay", " =) ", "o.o", "lol", "sorry", "wow", "hahaha", "OMG!!!"
PID4 Cohesive-Task	"Are you ok with everything before we agree?", "lets go", we click agree ah?", "shall we move on??", "ya, what's wrong?", "wait i help you solve"
PID5 Cohesive- Playful	"lets take a break!" "Can you tell me who are you??", "Do you want to know who I am?", "MERRY CHRISTMAS", "twinkle twinkle", "i spam ah"

PID6 Disaffective *(anti-PI)*	"What is this man! -_-", "I hate this thing", "howtodo?!!!", "anythin lor!!! not in CA [mid-year exam] oso!!", "I dunno how to find the stupid thing!", "$%^$%*$%^3E%u^)n*_#;" "I DONT KNOW HOW TO DO.", "i dk la dont fell like doing", "im bored", "zzzzzzzzzzzz"
PID7 Uncohesive *(anti-PI)*	"y r u so slowwwwwww", "man u r weird", , "faster!!", "dumb", "jerk", "dont sorry me", "i care ?", "wallawei [colloquial exclamation of frustration] jus y so many times i do also cannot go to nex pg y u didn say u agrere; waste so much time cause of u", "everytime u dk", "you then luh pig head"