Examining Dynamics of Implementing Flexible Group Discourse in a Principle-based CSCL Environment

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Abstract: This study aimed to examine the effect of flexible group collaboration on students' constructive discourse in a principle-based CSCL environment. The participants included 27 Chinese undergraduate students taking a 16-week introductory research methods course. The online discourse adopted a flexible collaboration structure: fixed small group collaboration in the first eight weeks, and opportunistic collaboration in the second eight weeks. The data were collected from students' online discourse notes and assignment tasks. Group differences in small group collaboration and differences between two collaboration structures were examined. Findings indicated that flexible collaboration design helped students to work towards constructive discourse progressively. The study also provided evidence of how students new to principle-based approach engaged in online discourse for conceptual understanding in the Chinese context.

Introduction

Most studies in CSCL area use the small group as the collaboration structure in classrooms. Empirical studies have identified that there can be different patterns of group interaction and discourse in a same learning environment. For instance, Hmelo-Silver (2003) uncovered possible group differences owing to the nature of knowledge that students created. Muukkonen and Lakkala (2009) stated that different groups may hold different epistemic goals in their online inquiry. In another study, different patterns of online discourse were identified: some groups focused on knowledge sharing while others concentrated mostly on knowledge construction or knowledge creation discourse (van Aalst, 2009). In addition, the importance of collaboration at the whole class level has also been pointed out. For instance, Sawyer (2003) argued that most social collaboration in real life is improvisational and that it is necessary to account for this characteristic in classroom collaboration. Online discourse can better cope with emergent learning needs and ongoing inquiry progress as students opportunistically choose collaborators. Zhang et al. (2009) studied three social configurations in the context of encouraging "collective cognitive responsibility" (i.e., knowledge building): fixed groups, interacting groups, and opportunistic groups. During opportunistic collaboration, a number of informal groups formed, disbanded, and recombined to pursue both individual and collective understanding. The examination of the participatory patterns as well as students' knowledge gains indicated that opportunistic groups facilitated knowledge advancement. But little is known whether this design can be generalized to different classroom settings.

In online discourse, students are not only expected to complete group tasks and share ideas; they are also expected to share responsibility to steering toward constructive knowledge work (Muukkonen, Lakkala, & Hakkarainen, 2005; Olson, 2003; Scardamalia & Bereiter, 2003). In other words, students should take the roles of being active agents in the process of externalizing cognition at collective levels along with social collaboration, so that knowledge can be discussed, co-constructed, and advanced. One innovative pedagogical approach that encourages and supports students as agents of their collaborative learning is principle-based, and provides principles rather than procedures to guide their work (Hong & Sullivan, 2009; Scardamalia & Bereiter, 2003). Previous studies (e.g., Lee et al., 2006; Zhang, 2011) posited that the application of such an approach in secondary and primary classrooms can facilitate students' collaboration and knowledge building. Despite much progress, principle-based approach remains rarely implemented, particularly in undergraduate classrooms. Different collaboration structures can be adopted only if they are in accordance with principles (Brown & Campione, 1996). To some extent, the small group is suitable for students who are novices in computer discourse, since there are limited numbers of notes to read and respond to, and it is easy to follow learning progress. By contrast, the whole-class discourse is more demanding as students should regulate their own learning continuously, in order to contribute to collective knowledge and benefit from opportunistic collaboration.

Therefore, this study proposed that the adoption of a flexible collaboration structure with a combination of fixed small group collaboration and opportunistic collaboration may be a more appropriate way of helping students engage in constructive discourse in a principle-based CSCL environment. Specifically, the study aimed to partially replicate Zhang et al.'s (2009) design implemented in a Western primary classroom to a one-semester undergraduate course in the Chinese context. The multi-faceted analysis was carried out to reveal possible group dynamics characterizing the nature of online discourse and their relation with conceptual understanding. The following three questions were addressed: (1) How did the different groups collaborate during fixed small group discourse? (2) Did the students go beyond fixed small group collaboration towards opportunistic collaboration productively? (3) What was the relation between group discourse dynamics and individuals' conceptual understanding?

Methods and Design

Participants and Instructional Design

The participants in this study were one class of 27 undergraduate students majoring in educational technology at a university in mainland China. A one-semester course entitled "Basic Research Methods" was divided into two 8-week phases. In the first phase, the students collaborated in fixed small groups, and in the second phase the whole class collaborated. There was one-hour, student-centered synchronous discourse in an online platform-Knowledge Forum (Scardamalia & Bereiter, 2003) arranged after regular two-hour lectures every week. The students had no previous experience of participating in online constructive discourse before, while the course teacher who had five years' experience of using online platforms to supporting students' constructive discourse. The course materials were divided into several discussion themes covering key concepts included in the textbook. The classroom activities included creating knowledge products (i.e. questionnaires, group reports) through designing and implementing small research projects, along with concept-learning inquiries for strengthening students' understanding. The main goals of group collaboration were: to develop students' responsibility for collaborative learning via conducting small group projects and concept-based discussion, and to help students to obtain deeper understanding of the nature of knowledge in the context of learning about research methods.

A principle-based CSCL environment was constructed based on the twelve knowledge building principles (Scardamalia, 2002). This study adopted four principles: (1) idea-centered progressive discourse; (2) community knowledge, collective awareness; (3) constructive use of information; and (4) monitoring and regulating discourse. These four principles were acceptable for new learners to understand practical meanings of using them (Lee et al., 2006; Hakkarainen, 2009). They could also avoid conceptual overlap and map out core features of the twelve knowledge building principles (Chan & Chan, 2011; van Aalst & Chan, 2007). The students were encouraged to use the above four principles as discussion norms, to work in small groups and then dig deeper to facilitate learning as a whole class. At the same time, scaffolds in Knowledge Forum such as "I need to understand", "Information", "My theory" were intended to support students' cognitive processing corresponding to basic ideas of the knowledge building principles. The students used these scaffolds when they created notes, raised questions, and replied to notes. In addition, the course teacher organized offline activities to facilitate students' online discourse. For instance, the teacher asked students to draw concept maps to frame and plan their online discourse, evaluate progression and constrains of ongoing collaboration based on the four principles.

Data sources and analysis

The data sources in this study included students' discourse notes posted to Knowledge Forum and assignment tasks arranged at the end of the course. Group discourse dynamics were delineated through analyzing social and cognitive indicators, which were measured through social network analysis (SNA) and content analysis. SNA is a quantitative method that reveals features of social structures formulated in a community (Haythornthwaite, 1996). In contrast, qualitative content analysis can uncover the nature of knowledge distributed over a particular network (Gunawardena, Lowe, & Anderson, 1997; Hmelo-Silver, 2003). The combination of these two methods, therefore, enables complement measurements and provides fruitful information about online discourse (De Laat et al., 2007; Lipponen et al., 2003).

The process of data analysis followed four steps. First of all, SNA was conducted to capture the general picture of collaborative networks generated in Knowledge Forum. Two measures: density and betweenness centrality were employed to evaluate unidirectional note reading and note responding interactivity. Density measured the intensity of interconnection among participants; while Freeman's betweenness centrality measured the extent to which this network showed equal and distributed interactions rather than dominated by a few participants (Scott 1991).

Secondly, content analysis was carried out to discern indications of the four principles and characteristics of knowledge distributed in group discourse. For this purpose, a coding scheme was refined through both theory-driven and data-driven approaches, using a note as the unit of analysis. As demonstrated in Table1, four main categories (question, idea, metacognition, and reference) identified were basically in line with the knowledge building principles. The first author rated all online discussion notes, and a second rater re-coded 30% of the notes independently. The inter-rater reliability measured by Pearson Correlation was .83. The proportion of each category of knowledge distributed in group discourse was then calculated, followed by a Chi-square test performed to examine possible group difference.

Thirdly, we used an inquiry thread as the unit of analysis to assess the patterns of group discourse and advances of collective knowledge. An inquiry thread was a number of notes that address the same principal problem, thus forming a conceptual stream plotted against a timeline (Zhang et al., 2007). Using this method, all the notes were reorganized into inquiry threads in terms of discourse themes being investigated. Then notes included in each thread were sequenced along the timeline of contribution. To trace the processes of constructive discourse and knowledge advances, we further classified two main categories: question and idea into several subcategories. According to Hakkarainen (2003), progressive constructive discourse can be characterized as the iterative process of questioning and explanation, with the shift from fact-oriented to explanatory-oriented knowledge. In van Aalst's (2009) study, questions were subcategorized as seeking facts, clarifications, or explanations; while ideas were classified into seven subcategories: fact, concept, elaboration, explanation, conjecture, opinion, and rise above. Based on these two coding schemes, top-down and bottom-up processes were performed to code all notes relating to questions and ideas. We then obtained the coding subcategories at four levels (from low to high): fact-oriented, clarification-oriented, elaboration-oriented, explanation-oriented question or idea, respectively. The possible knowledge advancement was then examined by assessing the changes of mean levels of questions and ideas produced in discourse threads. The first author rated all online discussion notes, and another researcher re-rated 30% of notes independently. The inter-rater reliabilities were calculated based on Pearson Correlation, to be .83 for question subcategory and .80 for idea subcategory, respectively.

Table 1: Operational definitions of coding categories in online discourse.

Category		Definition
Question	Fact-oriented	Ask for the definition of a concept or factual information
	Clarification-oriented	Ask for clarifying relevant elements or characteristics of a concept, or different opinion
	Elaboration-oriented	Ask for interpretation on relation, difference, practical meaning of certain opinion, claim, or theory
	Explanation-oriented	Ask for providing explanation on a particular theory or strategy of implementing a concept, theory, or claim
Idea	Fact-oriented	Point out a concept or factual information simply
	Clarification-oriented	State conceptual difference, similarity, characteristic, personal opinion or experience
	Elaboration-oriented	Elaborate a theory, claim, or opinion with specific statement
	Explanation-oriented	Explain a concept and theory with the support of relevant information, and example
Metacognition		Monitor, regulate or evaluate ongoing inquiry process and group collaboration progress
Reference		Introduce reference and information from an outside source without any additional interpretation

Finally, the students were asked to complete assignment tasks at the end of the course, so as to examine their understanding of core concepts relating to research methods that had been discussed on the phases of small group collaboration and opportunistic collaboration. These assignments were scored on a 4-point scale to evaluate individuals' conceptual understanding, following the scheme developed by van Aalst (2009) with the consideration of the degree of misunderstanding on key concepts and discourse themes being investigated. Details of this rating scale are shown in Table 2. Two raters scored all the assignments independently and the inter-reliability was .79 in terms of Pearson Correlation. A Pearson's correlation analysis was performed to test the relation between the indicators characterizing social and cognitive dynamics of group collaboration and individuals' conceptual understanding.

Table 2: The rating scale of evaluating students' assignment tasks.

Scale	Definition
1	Strong evidence of misunderstanding, without specific explanation of core concepts being investigated
2	Little evidence of misunderstanding, with vague and unclear explanation of core concepts being investigated
3	No misunderstanding, with explanation but lack of coherence and linking to related core concepts being investigated
4	No misunderstanding, with explanation having coherence and linking to related core concepts being investigated

Results

How did the different groups collaborate during fixed small group discourse?

Small group discourse was examined using social network analysis and content analysis, so that possible differences of group collaboration were disclosed. Overall, the students generated 660 notes in Knowledge Forum. In fixed group phase, the students were randomly assigned to 5 small groups to pursue conceptual learning and group project design for eight weeks. The degrees of group participation and patterns of interaction were calculated (see Table 3). There was no variation among five groups on note reading interactions, as shown by the highest reading density (100%) and lowest betweenness centrality (0.0%). This meant that each participant read their group members' notes actively, resulting in equal and distributed reading interactions occurred in the social networks. By contrast, some variations have been observed in note responding interactions. More interestingly, Group One and Group Two's measurements in interaction patterns showed the same results, with the highest density (100%) and lowest betweenness centrality (0.0%) values on both note reading and responding. It was obvious that all students in these two groups worked intensively with one another. To further uncover possible group differences, the subsequent analyses were carried out to test cognitive processing using quantifying content analysis (Chi, 1997).

Table 3: Patterns of social networks in small group collaboration (with Standard Deviations in Parentheses).

	Group 1 n=5	Group 2 n=5	Group 3 n=5	Group 4 n=5	Group 5 n=6
Mean number of notes	16.6 (4.3)	13.8 (3.7)	9.6 (2.1)	12.4 (2.3)	12.3 (3.8)
Note reading density	100%	100%	100%	100%	100%
Betweenness centrality of note reading	0.0%	0.0%	0.0%	0.0%	0.0%
Note responding density	100%	100%	90.0%	80.0%	93.3%
Betweenness centrality of note responding	0.0%	0.0%	2.8%	12.5%	1.00%

Note: One student was excluded from analysis as he started to attend the course near the middle of the semester.

Figure 1 shows the percentages of knowledge classified by four main categories: question, idea, metacognition, and reference. Apparently, the majority of notes produced by five groups referred to idea category. Each group also generated relative higher proportion of knowledge categorized as metacognition. There were noticeable variations on the proportions of question and reference categories among five groups. A Chi-square analysis confirmed that the distribution of knowledge differed significantly between groups across four categories (χ^2= 26.2, df = 12, p < .05). In particular, there was a substantial difference (χ^2= 23.6, df = 3, p < .001) between Group One and Group Two on the distribution of knowledge in terms of four categories, even though they displayed the same patterns of collaborative networks. It was apparent that Group One contributed higher percentage of question compared with other four groups. For Group Two, however, knowledge distribution was mostly dominated by idea, but there were fewer questions than other groups. Group One and Group Two were further selected to examine group discourse patterns and possible knowledge advances emerged in discourse threads.

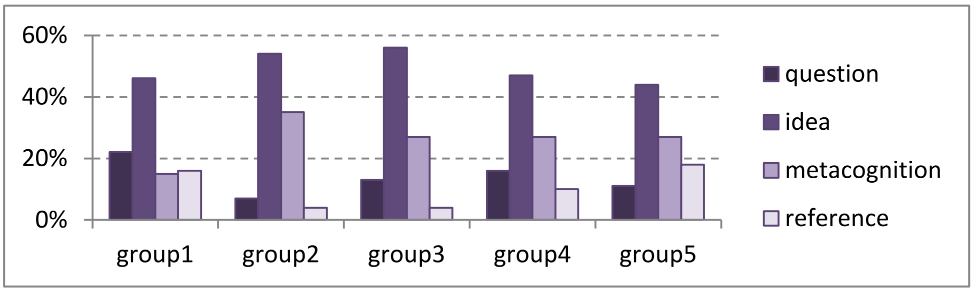

Figure 1. Percentage of different categories of knowledge in small group collaboration.

Overall, both groups formulated five discussion threads covering concepts related to research methods: research question, variables, sampling, interview and questionnaire. On average, there were 16.4 (SD = 12.9) and 13.4 (SD = 6.2) notes in each thread for Group One and Group Two, respectively. We evaluated all discourse threads produced in two groups in terms of the discourse patterns identified by van Aalst (2009). In Group One, two out of five discourse threads revealed knowledge construction, while rests of others remained at knowledge sharing; but for Group Two, only one discussion thread revealed knowledge construction. In order to uncover to what extent knowledge was advanced, all notes were reordered following the timeline of contributions in each discussion thread. We then divided notes in each thread into two periods with equal proportion of notes. The levels of questions and ideas in discourse threads across two periods were rated on a 4-point scale. As shown in Table 4, Group One generated relatively higher levels of questions and ideas than Group Two, and the mean levels of questions and ideas increased slightly through discourse as well. In Group Two, however, there was no increase observed in the means levels of questions and ideas across two periods. Results indicated that two groups performed differently in sustaining online discourse over time. Group One seemed to work productively towards constructive discourse compared to the counterpart. No statistical test was conducted due to small sample sizes ($n = 5$).

Table 4: Mean levels of questions and ideas for period 1 and period 2 in small group collaboration (with Standard Deviations in Parentheses).

	Question		Idea	
	Period 1	Period 2	Period 1	Period 2
Group 1	2.6 (1.1)	2.7 (1.2)	2.7 (1.0)	2.8 (1.8)
Group 2	2.3 (0.6)	2.3 (0.6)	2.4 (0.9)	2.3 (0.8)

Did the students go beyond fixed small group collaboration towards opportunistic collaboration productively?

To assess whether the flexible collaboration structure promoted students' productive discourse, we used the same data analysis procedures employed in addressing the first research question to evaluate possible group dynamics across two social configurations as well. On average, the students contributed 12.9 (SD = 3.8) and 12.0 (SD = 4.9) notes during small group and opportunistic collaboration, with relative consistent note contributions across two phases. Table 5 shows the patterns of social collaborative networks in two types of collaboration structures. Not surprisingly, the value (68.0%) of note reading density measurement of small group collaboration at the whole class level was much less than the values measured at the five small groups (100%) separately. In general, the rates of note reading and note responding densities increased from fixed small group collaboration to opportunistic collaboration, which indicated that the classroom interactivity had spread to more participants. Simultaneously, betweenness centrality of social collaborative network was calculated considering both note reading and note responding activities. The decreasing trend in this indicator implied that opportunistic collaboration made a broader scope of collaboration possible, resulting in relatively distributed and evenly social network occurred in the classroom.

Table 5: Patterns of social networks in two types of collaboration structures.

	Density of note reading	Density of note responding	Betweenness centrality of collaborative network
Small group collaboration	68.0%	16.6%	4.4%
Opportunistic collaboration	90.3%	21.9%	0.2%

The examination of different characteristics of knowledge (see Figure 2) created by the students found a significance difference on the distribution of knowledge between small group and opportunistic collaboration ($\chi^2 = 38.9$, $df = 3$, $p < .001$). It was apparent that the highest proportion of knowledge contributed by the students during group discourse was idea. Moreover, the students' engagement showed increasing proportions of questions and ideas from fixed small group collaboration to opportunistic collaboration. The subsequent analysis intended to uncover the possible knowledge advancement emerged in discourse threads.

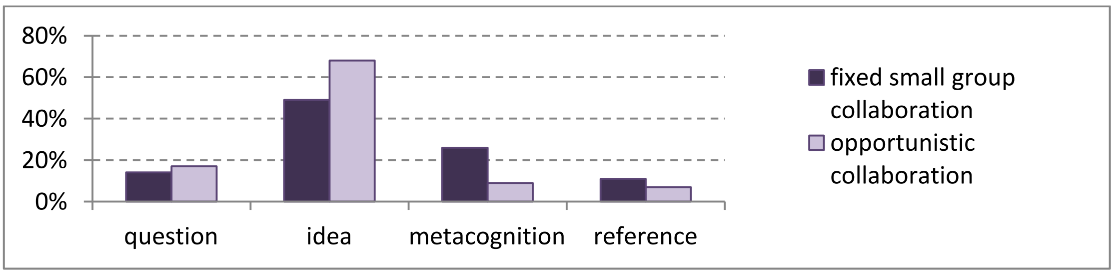

Figure 2. Percentage of different characteristics of knowledge in two types of collaboration structures.

Altogether, the 27 participants were involved in 33 inquiry threads during the semester. We assessed each thread according to the discourse patterns identified by van Aalst (2009). Five of twenty-three inquiry threads involved knowledge construction during small group collaboration, while six of ten threads revealed knowledge construction during opportunistic collaboration. All other threads were assessed as knowledge sharing discourse. In addition, the mean lengths of threads were 14.3 (SD = 8.3) notes for small group collaboration and 31.0 (SD = 22.2) notes for opportunistic collaboration. As found in previous analysis, knowledge construction discourse was examined to be more evident in promoting knowledge advances than knowledge sharing discourse. Five threads rated as knowledge construction discourse in each collaboration structure were selected to further investigate the degrees of knowledge advancement. As shown in Table 6, the mean levels of questions and ideas raised in the process of small group and opportunistic collaboration. It was noticeable that the mean level of questions in opportunistic collaboration was higher than that in small group collaboration. Also, the advancement of knowledge in opportunistic collaboration was more evident than in fixed groups. In addition, there was very little increase observed in the mean level of ideas contributed in two collaboration structures in the discussion threads. The results suggested that the students attempted to engage in constructive discourse by going beyond small group collaboration towards opportunistic collaboration progressively. During this process, the students made progress in generating higher level of questions. However, there was little improvement in contributing higher level of ideas. No statistical test was performed due to limited number of threads ($n = 5$).

Table 6: Mean levels of questions and ideas for period 1 and period 2 in two types of collaboration structures (with Standard Deviations in Parentheses).

	Question		Idea	
	Period 1	Period 2	Period 1	Period 2
Small group collaboration	2.4 (0.9)	2.8 (1.1)	2.6 (0.8)	2.7 (0.8)
Opportunistic collaboration	2.9 (1.2)	3.2 (1.0)	2.6 (0.7)	2.8 (0.7)

What was the relation between group discourse dynamics and individuals' conceptual understanding?

The above two research questions addressed discourse dynamics within and across groups by measuring social and cognitive indicators. The third research question moved to understanding how group collaborative dynamics impacted students' conceptual understanding by performing a Pearson correlation analysis. In general, the students' assignment tasks covered 18 inquiry threads discussed in Knowledge Forum. The assignments were scored to evaluate the degree of conceptual understanding for each individual student. At the same time, social and cognitive indicators corresponding to those 18 discussion threads were calculated. Table 7 shows the relationships among the indicators of group discourse dynamics and individuals' conceptual understanding.

Table 7: Correlations among indicators characterizing group discourse dynamics and conceptual understanding.

	note read	note respond	question	idea	metacognition	reference	level of questions	level of ideas
note respond	.63**							
question	.76**	.81**						
idea	.96**	.72**	.83**					
metacognition	.34	.33	.06	.25				
reference	.40	.34	.16	.36	.00			
level of questions	.65**	.72**	.61**	.74**	.18	.40		
level of ideas	.28	.40	.17	.34	.20	.19	.55*	
conceptual understanding	.64**	.53*	.50*	.64**	.34	.27	.59**	.31

Note: *p < .05, **p < .01

Results found that the numbers of note reading and note responding indicators in each discussion thread were significantly correlated to students' conceptual understanding ($r = .64$, $p < .01$; $r = .53$, $p < .05$). Of four indicators characterizing different types of knowledge contributed in online discourse, question and idea were correlated significantly to conceptual understanding ($r = .50$, $p < .05$; $r = .64$, $p < .01$). However, no significant correlation was found among the numbers of metacognition, reference contributed in the discourse threads and conceptual understanding. The statistical result demonstrates that the mean level of questions contributed to conceptual understanding positively ($r = .59$, $p < .01$). In addition, the mean level of questions significantly correlated to the level of ideas ($r = .55$, $p < .05$). Yet, there was no significant relation found between the mean level of ideas and conceptual understanding. The results suggested that contributing larger numbers of ideas and questions could facilitate students' conceptual understanding. In particular, questioning played an important role in deepening understanding.

Discussion and Conclusion

The purpose of this study was to investigate the effect of combining fixed small group and opportunistic collaboration to facilitate Chinese undergraduate students' constructive discourse in a principle-based CSCL environment. Departing from the earlier research that adopted opportunistic collaboration in a Western primary classroom, the current study extended the design in a Chinese context by integrating online discourse into a regular undergraduate course.

The present study did not simply replicate methods of the earlier study that primarily compared social structures and processes at a class level across three successful years. Rather, the study targeted at another angle by examining group collaboration dynamics at three aspects: patterns of social interaction, characteristics of knowledge distributed within groups, and knowledge advances emerged along discourse threads. This kind of multi-faceted analysis not only validated the findings against the previous research, but also uncovered fine-grained dynamics of online group discourse. The examination of group collaboration in fixed small groups found that all five groups showed intensive collaboration, but they differed substantially on contributing different characteristics of knowledge. In particular, two small groups with the same interaction patterns showed large variations in the knowledge distribution and knowledge advancement. It implied that intensive group interactions might not necessarily lead to higher cognitive processing. Moreover, social network analysis revealed that social interactivity spread to more participants from fixed small group collaboration to opportunistic collaboration and this extended scope of group collaboration promoted relative equal interactions in the class, which was compatible with the findings from the previous study (Zhang et al., 2009). Apart from examining the positive impact of changing group configuration on individuals' knowledge gains that has been reported in Zhang et al.'s (2009) study, the present study also tested associations between the indicators characterizing social and cognitive dynamics and students' conceptual understanding. Consistent with Hakkarainen's (2003) study that uncovered the important roles of questions in deepening understanding, data analysis found that both the number and level of questioning were positively correlated to individuals' conceptual understanding. It was noteworthy that the majority of knowledge produced by the students refereed to idea. However, the level of ideas did not change greatly in discussion threads and it was also not significantly correlated to conceptual understanding, whereas the number of ideas was positively correlated with conceptual understanding. One reason may be because the students encountered difficulties in improving ideas collectively. Another possible reason is that discourse itself encompasses the interplay between different levels of knowledge, which caused the advancement of ideas along inquiry threads was slower than expected.

To conclude, this study supported the advantage in facilitating students' constructive knowledge work through flexible collaboration design in a principle-based CSCL environment. The examination of students' online discourse and assignment tasks revealed how Chinese undergraduate students new to principle-based approach and constructive discourse could go beyond small group collaboration towards opportunistic collaboration in advancing individual and collective understanding progressively. Additionally, the study provided an example of integrating social network analysis and content analysis to uncover interdependent roles of social and cognitive dynamics in online discourse. Owing to the limitation on small sample size, further studies are needed to validate the findings in various classroom settings. It would also be valuable to trace how opportunistic groups emerge and how individual students benefit from and contribute to group collaboration.

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