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Fixed group and opportunistic collaboration in a CSCL environment

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Abstract This study investigated synchronous discourses involving student collaboration in fixed groups during an introductory research methods course's first 8-week phase, and opportunistic collaboration during its second 8-week phase. Twenty-seven Chinese undergraduates participated in online discourse on Knowledge Forum as part of the course. A multi-faceted analysis was performed to examine different aspects of collaboration – interaction patterns, knowledge characteristics distributed over inquiry, discourse patterns, and knowledge advances that emerged from discourse threads. The results show little variation in social interactions, but substantial differences in knowledge distribution between fixed groups. Groups that were productive in constructive discourse tended to generate higher-level questions and ideas. When engaged in opportunistic collaboration, the students were capable of engaging in a large range of interactions and of contributing higher-level questions and ideas; however, they were constrained by making little use of metacognition and having scattered interactions. Additionally, this study tested the relationship between online discourse and individual performance in the end-of-course assessment tasks. The results indicate that actively participating and contributing high-level ideas were positively correlated with students' domain knowledge. The study's implications for understanding online discourse dynamics within and across fixed groups and opportunistic collaboration in a computer-supported collaborative learning (CSCL) environment are discussed.

Keywords Online discourse · Opportunistic collaboration · Fixed groups

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Introduction

A principal area of study in the literature on computer-supported collaborative learning (CSCL) is asynchronous and synchronous discourse, through which students share ideas and co-construct knowledge (Muukkonen et al. 2005; Rourke and Kanuka 2007; Yap and Chia 2010). Students are expected to be active agents in externalizing cognition and enabling social collaboration, so that knowledge can be discussed, co-constructed, and advanced (Arvaja et al. 2007; Schrire 2006; Suthers et al. 2008; Veerman et al. 2000).

In their classroom collaborations, students are usually organized into small groups to complete certain tasks; in this paper, we refer to these as *fixed groups*. Individual students can learn far more in fixed groups than they can on their own (e.g. Johnson and Johnson 1994; Stahl 2006). However, it has been shown that fixed group collaboration can lead to significant disparities between the group's overall learning performance and that of individual learners (Barron 2003; Webb et al. 1998, 2002). This may arise from differences in student efforts and competence, or from the size of the group or nature of the task. Individual and group learning are therefore both sensitive to the composition of fixed groups, and alternative or complemetary strategies might be required.

The learning or knowledge-building community (Bielaczyc and Collins 1999; Scardamalia and Bereiter 2006) involves another type of social configuration, *opportunistic collabroaiton*, which has more emergent and dynamic characteristics. Participants opportunistically select collaborators depending on the particular problem, disband the group when the problem has been solved, and form new groups to achieve subsequent goals. Zhang et al. (2009) have argued that such *opportunistic collaboration* is superior to both fixed independent groups and fixed interacting groups, in terms of online participatory patterns, depth of inquiry, and individual student gains. How different configurations shape variances in interactions and cognitive processes remains, however, unclear. This is particularly pertinent in online discourse, where there is no direct teacher involvement. Zhang et al. (2009) study was conducted in a Grade Four class studying optics; students of that age often have considerable curiosity and are able to sustain their learning over long periods. What would be the results if the curriculum were more advanced, the students more task-oriented, and more emphasis were placed on examination results? Higher education in China provides such a context.

The aim of this study was to explore students' synchronous discourse in an online platform (Knowledge Forum), first through fixed groups, and then through opportunistic collaboration, in a Chinese undergraduate course. We used a multi-faceted analysis to examine students' online discourse in the two social configurations, and its relationship to domain understanding.

Fixed group collaboration

In most classroom discussions, students work in groups to complete tasks that may last for a single lesson or continue over many weeks. Students may be randomly assigned to groups by the teacher or choose their own group; knowledge of students' social and cognitive abilities and interests may influence how teachers assign them. Once assigned, each group undertakes its own task and group membership remains fixed throughout.

Fixed groups are effective in negotiating and generating consensus (Strijbos et al. 2004) and often feature intensive engagement and interaction (Kim 2013; Qiu et al. 2012). Previous studies have shown that fixed groups' achievements are greater than the sum of their individual members' (e.g. Johnson and Johnson 1994; Stahl 2006). This social configuration can, however, lead to problems. In Barron's (2003) study, for example, different groups with similar prior knowledge of and abilities in mathematics demonstrated substantial differences in group performance, depending on participants' social competence. Previous studies have shown that a fixed group configuration can often lead to substantial inequality in learning; whether there is a high-ability student in the group can affect both overall and individual learning (Webb et al. 1998, 2002). The effects of group size have also been demonstrated. For example, in larger groups there may be a more extraneous cognitive load—a requirement for short-term memory that does not contribute to learning (see Kirschner et al. 2006)—but in smaller groups there may not be sufficient idea diversity to make conceptual progress (Hewitt and Brett 2007; Kim 2013; Qiu et al. 2012). A complex interweaving of numerous variables, such as the nature of the task, group size, and group composition, may affect group collaboration and learning (Dillenbourg 2002). Decades of experimental studies into fixed groups have highlighted the difficulties of investigating group effectiveness and of generalising experimental results to classroom settings. Many researchers have emphasized the need to explore group processes and interactions in real classrooms (Blatchford et al. 2003; Dillenbourg et al. 1996).

Recent empirical studies have found that different patterns of group interaction and discourse can co-exist in the same computer-supported collaborative learning (CSCL) environment. Hmelo-Silver (2003) discovered that the kinds of knowledge students create leads to group differences. Muukkonen and Lakkala (2009) indicated that the online inquiries of different groups may have different epistemic goals. Van Aalst (2009) identified different patterns of online discourse, with some groups producing knowledge-sharing and others producing knowledge-construction or -creation discourse. The aim of knowledge-sharing discourse is to accumulate information or share ideas, while knowledge-construction or knowledge-creation discourses tend to achieve deeper understanding through solving problems communally or creating new knowledge.

The above review suggests that there is a growing understanding of how individuals function in groups, but that how group collaborations mediate different patterns of discourse and learning outcomes in real classrooms is not well understood. Group learning often bridges both individual and community learning (Stahl 2013b), and it is common for online discussions to take place in fixed groups. Thus, it is worthwhile to investigate the dynamics and differences of these groups, in the same learning environment, to determine the factors that influence effective collaboration.

Opportunistic collaboration

In a learning or knowledge-building community, the social configuration involved in class-wide online discourse is emergent and flexible. Participants may opportunistically choose collaborators based on their own interests and particular learning needs. Small groups may be formed to discuss a particular problem at some times, while collaboration may involve virtually the whole class at others. Throughout the collaboration, a number of informal groups are formed, disbanded and recombined to pursue both individual and collective understanding. This opportunistic collaboration (Zhang et al. 2009) has been shown to stimulate the generation of divergent ideas in classrooms (Hewitt and Brett 2007; Szewkis et al. 2011). The increased whole-class input required can often, however, bring about an extraneous cognitive load, leading students to lose their sense of group belonging or connectedness. Compared to fixed groups, in which there are fewer computer notes to read and respond to, and in which it is easier to follow the inquiry process, opportunistic collaborations are more demanding, in that students need to continuously regulate their own learning if they wish to contribute to the collective knowledge and benefit from online discourse. These challenges can be significant, but the potential for opportunistic collaboration at the whole class level should not be overlooked.

Social collaboration in real life is improvisational, and should be allowed for in classroom collaboration (Sawyer 2003). Zhang et al. (2009) studied three social configurations—fixed groups, interacting groups, and opportunistic collaboration—in the context of investigating topics concerning optics through knowledge-building discourse. Three successive classes of Grade Four students took part in the study. In the first class, collaboration took place within separate, fixed sub-groups, while the second class engaged in cross-group collaboration and the third featured class-level, opportunistic collaboration. Opportunistic collaboration was found to be superior to the other two configurations in terms of participatory patterns, depth of inquiry and depth of knowledge understanding over five mothes of online discussions. One of the key factors in explaining these effects was the role of the teacher. The fixed independent groups featured few interactions between groups, and the teacher acted as an information broker. In the interacting fixed group configuration, there were more interactions between groups, but the teacher was still central to the social structure of the class community. In the opportunistic collaboration, the social position of the teacher, who still made important contributions to the discourse, became similar to that of the students. It can be hypothesed that community learning is less sensitive to the constraints of fixed groups, since students may collaborate within different emergent groups over time, and reduces the teacher's social network prominence, thus potentially activating students' self- and co-regulation of learning.

Zhang et al. (2009) study showed the benefits of opportunistic collaboration, but did not empirically demonstrate how different configurations shape variances in interaction and cognitive processes. Whether it is possible to generalize the observed effects to other domains and learning contexts is not known, and it is questionable whether the results would apply to the context of online discourse without a teacher's engagement. Children in Grade Four often have considerable curiosity and can become engrossed in their learning, when given the freedom to sustain their inquiries beyond the requirements of a course syllabus. The context of Chinese undergraduate classrooms, where curriculum is more advanced, students more task-oriented and exam performance more emphasised, is quite different, and little is known about how students collaborate in this configuration.

Combining two social configurations

Different social configurations can be combined during a single course for various purposes. In some courses, working in fixed groups provides a basis for class-wide collaboration, as students discuss learning topics within their own groups first, before presenting their conceptual products in whole-class discussions (Cornelius et al. 2013; De Simone 2008). In other courses, the social configuration is intended to accommodate specific learning tasks or class projects phases (Dillenbourg 2002; Jahng et al. 2010). Previous CSCL literature has suggested that productive collaboration can be driven by integrating different social configurations. For example, an empirical study by Woodruff and Meyer (1997) showed that inter- and intra-group discussions tend to stimulate scientific inquiry among students. Tabak and Reiser (1997) demonstrated how teacher-student interactions within fixed groups and whole classes provide students with more learning opportunities than working in any single particular configuration.

Combining different social configurations is, of course, common in classrooms, and can be seen as a way to script (Dillenbourg 2002) or scaffold a learning process (Puntambekar and Kolodner 2005; Tabak 2004). A review of the CSCL literature revealed that whole class discussions are mainly used as a framework for supporting cross-group interactions, or for sharing group products within a class-wide public space. However, the potential dynamics of opportunistic collaboration, which might permeate the whole class discussion, are often neglected. Most studies have investigated collaboration and online discourse within a particular social configuration, with little attention being given to how students approach learning through different configurations in the same course. Stahl (2013b) stated that online discourse involves individual, group and community levels of learning, mediated by the proliferation of computer notes as interactional resources. It is particularly important, then, to study online discourse at different levels within a single course and establish relationships among the levels (Stahl 2006, 2013a). An empirical investigation combining fixed groups and opportunistic collaboration involving different levels of analysis would, in part, serve this interest.

Gradually increasing the complexity of the social environment has been used extensively in studies of CSCL (e.g. Lee et al. 2006; van Aalst and Chan 2012). We hypothesized that, while opportunistic collaboration would be a more effective means of supporting collaborative learning, as suggested by Zhang et al. (2009), it would be psychologically better for students to begin their online discussions in fixed groups, developing their collaborative practices and preparing for the second configuration. We therefore combined fixed groups with opportunistic collaboration in a single course. According to social culture and group cognition perspectives, online discourse involves complicated social and cognitive dynamics that facilitate collaboration and learning (Beuchot and Bullen 2005; Hmelo-Silver 2003; Kumpulainena and Mutanenb 1999). This study therefore applied a multi-faceted analysis (involving social network analysis (SNA) and content analysis) to assess online discourse and to examine its potential relationship to individual learning throughout the course. The following research questions were proposed:

1. How did students in different groups engage in online discourse during the fixed group collaboration phase?
2. How did students engage in online discourse during the opportunistic collaboration phase, after their initial experience in fixed group collaboration?
3. What was the relationship between online discourse and individuals' domain understanding?

Methods and design

Participants

The participants were 27 Chinese undergraduate students (10 male and 17 female) taking a course on research methods as part of a pre-service teacher education curriculum. The students were majoring in educational technology, were in their third year of studies, and were between 20 and 23 years of age. The students knew each other well, as they had shared many courses in their time at the university. However, none of their previous courses integrated online discussions with regular classroom activities. The course teacher (the first author) had more than 5 years' experience in using online discussions to support constructive discourse in classrooms.

Curriculum and instructional design

Course design

The main objective of the course was to help undergraduates learn fundamental concepts related to research methods in the field of educational technology. To incorporate online discourse into the regular undergraduate course, we divided the course materials into several themes, so that students could cover the key concepts included in the course syllabus—variables, validity and reliability, experimental study, and action research—and prepare for the course examination. The course materials were reorganized, establishing an unfolding process driven by the students' emergent inquiry goals that suited the progressive nature of the curriculum design (Caswell and Bielaczyc 2001).

Pedagogical and technical supports for the online discourse

The development of the instructional environment was based on four principles: (1) collective knowledge and shared goals; (2) idea-centered progressive discourse; (3) constructive use of information; and, (4) monitoring and regulating discourse. These principles were not strictly based on knowledge-building theory; however, they covered the same aspects of collaborative inquiry in a community as did those used by Zhang et al. (2007) and were consistent with those used in studies of knowledge building in East Asia (Lee et al. 2006; van Aalst and Chan 2007).

The students were encouraged to use these principles as discussion norms, to work in fixed groups, and then to dig deeper to facilitate whole-class learning for opportunistic collaboration. Each week, after a 2-hour lecture, students participated in a 1-hour, student-centered synchronous discourse using the online platform Knowledge Forum® (Scardamalia and Bereiter 2003). The scaffolds in Knowledge Forum—such as "I do not understand," "New information," and "My theory"—are intended to support students' cognitive processes in relation to the principles. The students used scaffolds as sentence starters when creating notes, raising questions, or replying to other inputs. The course teacher also created different discussion spaces ("views") in Knowledge Forum; in these, students could collaborate either as part of a separate fixed group, or by discussing topics more widely through opportunistic collaboration, as they concentrated on various inquiry themes during different phases of the course.

The teacher used direct teaching to broaden the students' domain knowledge during offline class sessions (lectures), due to a need to maintain traditional course arrangements (i.e., scheduled lecture periods) and the need for direct instruction in the inquiry process (Hmelo-Silver et al. 2007). Various offline activities were also organized. For example, the teacher asked students to draw concept maps to frame and plan their online discourse, and to evaluate the progress of or constraints to their ongoing online discussions, based on the four above principles. The following three findings from the field of learning sciences were used as references (OECD 2008):

1) Learning should go beyond superficial facts and procedures to pursue deeper conceptual understanding.
2) Interconnected and coherent knowledge is more important than compartmentalized knowledge.
3) Learning in authentic contexts is more fruitful than learning through decontextualized classroom exercises.

Structuring online collaboration

The main goals of the online discourse were to develop the students' responsibility for constructive learning by conducting small group projects and concept-based discussions, and to help them to obtain a deeper understanding of research methods.

We divided the 16-week course into two equal phases. In the first 8 weeks (Phase 1) students were randomly assigned to groups of five or six, and designed small research projects in their own Knowledge Forum "views." Group members were expected to share their questions and ideas through the online platform in ways that exchanged knowledge about research methods, and helped in the co-designing of their group projects. In the last 8 weeks (Phase 2), all students worked in the same "views," and a variety of opportunistic collaboration groups were expected to emerge, based on shared interest in specific discussion topics. During this phase, students discussed difficult concepts in several focal inquiry themes, so discussions were more public and dealt with more theoretical material.

Data sources and analysis

The data sources in this study include the computer notes students posted on Knowledge Forum and two offline writing tasks they were asked to complete (individually) at the end of the course. The fixed groups and opportunistic collaborations were examined using SNA and content analysis. SNA is a method that reveals the quantitative features of participation and interactivity in a particular social structure (Haythornthwaite 1996; Scott 2000); content analysis can reveal the quality of knowledge contributions distributed in a collaborative network (Gunawardena et al. 1997; Hmelo-Silver 2003), but often does not consider interactivity. The combination of these two methods enables complementary measurements and provides holistic information about the online discourse (De Laat et al. 2007; Lipponen et al. 2003). Moreover, we conducted *inquiry thread analysis* (Zhang et al. 2007) to explore discourse patterns and possible collective knowledge advances. The data analysis followed four steps, as described below.

Social network analysis

Social network analysis (SNA) is an analytical method that evaluates the properties of social structures (Haythornthwaite 1996) that cannot be addressed by traditional quantitative and qualitative measures (Reffay and Martínez-Monés 2013). We carried out SNA using software called Ucinet 6.0. Q4

Two variables, *network density* and *betweenness centrality*, were used to evaluate unidirectional note-reading and note-responding activities. Network density is defined as the number of actual connections that exist in the social network divided by the maximum number of connections (Scott 1991), and is expressed as a percentage. In online discourse, a higher density value indicates that more participants are interacting with one another in the network. Freeman's betweenness centrality can be measured at both the network and individual levels. The indicator, centralization index, delineates the degree to which a network shows decentralized or distributed interactions (Scott 2000); its value becomes higher when there are more variations in the degree of links among nodes (participants), and is at its lowest when all nodes (participants) for that network are connected to one another. For individuals, betweenness centrality delineates the extent to which each member of the network interacts with others; if one participant has a high centrality value, s/he occupies a central position in the network and is more influential during interactions.

We also carried out *clique analysis* to identify sub-networks (or sub-groups) that emerged through responsive interactions. A clique here describes a sub-group structure in which a large number of members connect with a network density of 100 % (Wasserman and Faust 1999). The number and size of cliques generated in a social network indicates the intensity of interactions among particular group members (Haythornthwaite 2002). Students who are members of more than one clique often perform bridging roles between cliques, and may facilitate flows of knowledge between sub-groups (Aviv et al. 2003).

Content analysis

Content analysis is used widely in the CSCL literature to examine the qualitative features of discourse. One or more codes are applied to a computer note or smaller body of text (Chi 1997) and the resulting frequencies submitted to statistical analysis. Generally, coding schemes have few codes (i.e., categories), which can be applied with a high degree of inter-coder reliability (see De Wever et al. 2006).

We applied content analysis, based on the four aforementioned principles, to evaluate the characteristics of knowledge. The coding scheme was refined through both theory- and data-driven approaches, using students' notes as the units of analysis. As demonstrated in Table 1, the four main categories identified—question, idea, metacognition, and reference—were in line with the principles. Nine notes referring to group products uploaded in Knowledge Forum were excluded, and then the first author rated 651 online discussion notes, 30 % of which were then coded by an experienced coder from our extended research group. The inter-coder reliability was .83 (Cohen's kappa). The proportion of each category of knowledge distributed through collaboration was then calculated, followed by a Chi-square test, performed to examine possible differences between groups or social configurations.

Inquiry thread analysis

We used the inquiry thread as the unit of analysis when assessing patterns of online discourse and advances in collective knowledge. An inquiry thread is a series of notes addressing the same principal problem, and thus forms a conceptual stream that can be plotted against a timeline to denote the flow of knowledge processing (Zhang et al. 2007). Using this method, all of the students' notes were reorganized into inquiry threads relating to the discourse themes being investigated, and then sequenced along the contribution timeline. To trace constructive discourse processes and advances in knowledge, we further divided 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 explaining, with a shift from fact- to explanation-oriented knowledge. In van Aalst's (2009) study, questions were subcategorized as seeking facts, clarifications, or explanations. 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 *question* and *idea*. We then obtained coding subcategories at four levels (from low to high): fact-oriented; clarification-oriented; elaboration-oriented; and, explanation-oriented questions or ideas. Here, clarification refers to questions or statements about differences, similarities and characteristics of components included in a single concept or between two concepts; elaboration refers to computer notes reflecting students' efforts to question/state a theory, claim or personal opinion. The degree of knowledge advancement within an inquiry thread was then examined by assessing changes in the mean levels of the t1.1 **Table 1** Coding scheme used in content analysis

	Category		Definition and note example (translated from Chinese)
t1.2	Category		Definition and note example (translated from Chinese)
t1.3	Question	Fact-oriented	Ask for the definition of a concept or factual information (e.g. *[I do not understand] what a positivist/empiricist paradigm is?*)
t1.4		Clarification-oriented	Ask for clarifying relevant elements or characteristics of a concept, or different opinion (e.g. *[My question] Which is the purpose of falsification, validity or reliability?)*
t1.5		Elaboration-oriented	Ask for interpretation on relation, difference, practical meaning of certain opinion, claim, or theory (e.g. *How do we understand these accumulative percentages reported in the College English Test Band 4?*)
t1.6		Explanation-oriented	Ask for an explanation of a particular theory or strategy of implementing a concept, theory, or claim (e.g. *[I do not understand] "Action research can be understood as the sum of many experimental studies. It is a method that is based on experimental study." Could you please explain it clearly?*)
t1.7	Idea	Fact-oriented	Point out a concept or factual information simply (e.g. *Sampling methods include random sampling, systematic sampling, convenience sampling, stratified sampling, cluster sampling, judgment sampling, quota sampling, snow sampling,* etc.)
t1.8		Clarification-oriented	State conceptual difference, similarity, characteristic, personal opinion or experience (e.g. *Interview includes semi-structured interview and structured interview. The former follows pre-designed procedure to conduct an interview . . . The latter doesn't need to follow any specific procedure*).
t1.9		Elaboration-oriented	Elaborate a theory, claim, or opinion with a specific statement (e.g. *[My theory]The results can be generalized to more students if we randomly select students from different grades. I think we also need to select samples according to different subjects. In this way, we can avoid some bias caused by subject differences when we conduct interviews*).
t1.10		Explanation-oriented	Explain a concept and theory with the support of relevant information, and examples (e.g. *This question can be explained by the case study on a student, Wang XX. The study intended to explore the [school dropout] phenomenon through answering the question why he dropped out of school and possible reasons behind it . . . We may find some other research questions by conducting the same research).*
t1.11	Metacognition		Monitor, regulate, or evaluate ongoing inquiry process and group collaboration progress (e.g. *The problem: 1. Some questions did not get prompt responses. 2. Some ideas have not been expressed clearly in the platform.*)
t1.12	Reference		Introduce reference and information from an outside source without any additional interpretation (e.g. *[New information] Action research mainly conducted in the original population. If it refers to an experimental treatment, this research should also be a quasi-experimental study).*

questions and ideas produced in the discourse threads. The first author rated all of the online discussion notes, 30 % of which were then rated independently by another researcher. The inter-rater reliability was .79 for questions and .77 for ideas (Cohen's kappa).

Each discourse pattern was also classified using van Aalst's (2009) scheme. The main criteria for distinguishing between knowledge sharing, knowledge construction and knowledge creation threads were, first, the extent to which students concentrated on the focal problems being investigated and, second, whether this common goal was achieved through online discourse. If there was a common goal, but the students accumulated information or shared ideas without reaching agreement or solving problems, we identified the thread as *knowledge sharing*. If a thread showed evidence of constructing understanding and solving problems around the focal problem under discussion, it was classified as *knowledge construction*. If a thread showed evidence of not only solving the focal problem under discussion, but also creating knowledge beyond that already known by the group, it was classified as *knowledge creation*. Two coders independently classified all of the inquiry threads, obtaining an inter-rater reliability of .77 (Cohen's kappa).

Independent assessment of domain knowledge at the end of the course

Measures based on SNA and content analysis can be correlated with external measures of knowledge to see how contributions to an online discourse (posting and reading, interaction, and quality of content) correlate to conceptual or epistemic change (Hakkarainen et al. 2002; Lam and Chan 2008; Lee et al. 2006). Similarly, we used correlation analysis to test possible relationships between individuals' online engagement and their domain understanding.

At the end of the course, participants were asked to complete two assessment tasks demonstrating their understanding of the research methods' core concepts. Each student completed two tasks concerning, respectively, the knowledge discussed in fixed groups, and the topics discussed in opportunistic collaborations. The first task involved writing a research design report, including the group project's research goal, and the variables (or hypotheses) addressed and methods used in the project's design. The rating scheme therefore mainly evaluates the extent to which students correctly articulated the implementation of each concept, and whether they could consistently describe the project design components. The second assignment concerned the articulation and understanding of several of the main problems discussed in the online platform. Each problem referred to more than two concepts discussed, so the evaluation of this task was based on degrees of misunderstanding and whether a coherent explanation were offered for the specific problem. The two assessments were scored on a six-point scale to rate the individuals' conceptual understanding. Details of the rating scale are shown in Table 2. Two raters scored all of the data independently, and the inter-reliability was .72 (Cohen's kappa).

Results

We first report the data analysis derived from the fixed group collaboration, followed by the analysis relevant to opportunistic collaboration, and then report the results of the correlation analysis of online discourse and students' domain understanding.

Collaboration patterns during the fixed group collaboration

Structure of social networks during Phase 1

Table 3 shows the degrees of participation and patterns of interaction for each group. The students in Group 1 wrote more notes than those in the other four groups, while those in Group 3 wrote substantially fewer. There was no variation among the five groups in terms of note reading interactions, as all groups showed the highest reading density (100 %) and lowest t2.1 **Table 2** Rating scale for evaluating student assignment tasks

	Scale	Definition
t2.3	1	More than three strong pieces of evidence of misunderstanding about the core concepts Without a consistent explanation between the components of the group project being designed (task 1) Without a clear explanation of the problem being investigated (task 2)
t2.4	2	Two explicit pieces of evidence of misunderstanding about the core concepts Without a consistent explanation between the components of the group project being designed (task 1) Without a clear explanation of the problem being investigated (task 2)
t2.5	3	One explicit piece of evidence of misunderstanding about the core concepts A lack of clear and consistent explanation between the components of the group project being designed (task 1) A vague and unclear explanation of the problem being investigated (task 2)
t2.6	4	Little evidence of misunderstanding about the core concepts A lack of clear and consistent explanation between the components of the group project being designed (task 1) A vague and unclear explanation of the problem being investigated (task 2)
t2.7	5	No misunderstanding about the core concepts A lack of clear and consistent explanation between the components of the group project being designed (task 1) A lack of coherence explanation of the problem or linkage between the core concepts being investigated (task 2)
t2.8	6	No misunderstanding about the core concepts A clear and consistent explanation between the components of the group project being designed (task 1) A clear explanation of the problem, having coherence and linkage between the core concepts being investigated (task 2)

betweenness centrality (0.0 %). In contrast, some between-group variations (ranging from 0.0 to 12.5 %) were observed in note responding interactions. Group 4 showed much more centrality, whereas the centrality values of the other groups were relatively low. Both Group 1 and 2 members connected with each other as one clique without new sub-group generation. Among the other three groups, two sub-groups emerged with clique sizes smaller than their

t3.1 **Table 3** Patterns of social networks in fixed groups (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
t3.3	No. of notes	16.6 (4.3)	13.8 (3.7)	9.6 (2.1)	12.4 (2.3)	12.3 (3.8)
t3.4	% note read	79.6 (12.1)	84.2(17.1)	81.6 (10.1)	74.6 (20.5)	64.2 (19.6)
t3.5	No. of note responses	13.2 (7.3)	11.6 (4.8)	7.2 (2.2)	10.2(1.3)	8.0 (2.8)
t3.6	Note reading density	100 %	100 %	100 %	100 %	100 %
t3.7	Betweenness centralization of note reading	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %
t3.8	Note responding density	100 %	100 %	90.0 %	80.0 %	93.3 %
t3.9	Betweenness centralization of note responding	0.0 %	0.0 %	2.8 %	12.5 %	1.00 %
t3.10	No. of cliques	1	1	2	2	2
t3.11	Clique size	5.0 (0.0)	5.0 (0.0)	4.0 (0.0)	4.0 (0.0)	5.0 (0.0)
t3.12	Each student belongs to cliques	1.0 (0.0)	1.0 (0.0)	1.6 (0.6)	1.6 (0.6)	1.7 (0.5)

Note: One student was excluded from the analysis, as he only attended the course near the middle of the semester fixed groups. These results were close to expected levels of collaboration, viz., that all participants would read and respond to each other's notes and formulate decentralized networks.

Interestingly, the measurements for interaction patterns in Groups 1 and 2 were the same, having the highest density (100 %) and lowest betweenness centralization (0.0 %) values for both note reading and responding. This means that each participant read and responded to all other group members' notes actively, resulting in equal and distributed interactions in the social networks. To discover more possible group differences, subsequent content analyses examined cognitive processing in each group.

Questioning, ideation, metacognition, and referencing

Figure 1 categorizes notes according to the four main knowledge categories (question, idea, metacognition, and reference), expressed as percentages. The majority of notes contained *ideas*, ranging from 42 to 61 % among the five groups. Each group also generated a relatively high proportion of knowledge categorized as *metacognition*. There were noticeable variations in the proportions of *question* and *reference* categories among the five groups. For instance, Group 1 wrote the most questions and Group 5 made the largest number of references. A Chi-square analysis confirmed that the distribution of knowledge differed significantly between groups across the four main categories, χ^2 (df=12, 336)=29.5, p<.01.

A follow-up comparison found that Groups 1 and 2 differed substantially (χ^2 (df=3, 152)= 15.9, p<.01) in distribution of knowledge among the four categories, even though they displayed the same patterns of social networks. It was noted that Group 1 members contributed a higher percentage of questions, about 22 % of all contributions. In Group 2, however, knowledge distribution was mostly dominated by ideas and metacognition, with very few questions (7 %). The analyses raised further questions about whether and how knowledge distribution differentiates knowledge-processing within these five groups. Further analysis was therefore carried out to examine possible differences in discourse patterns and knowledge advances that emerged from the inquiry threads.

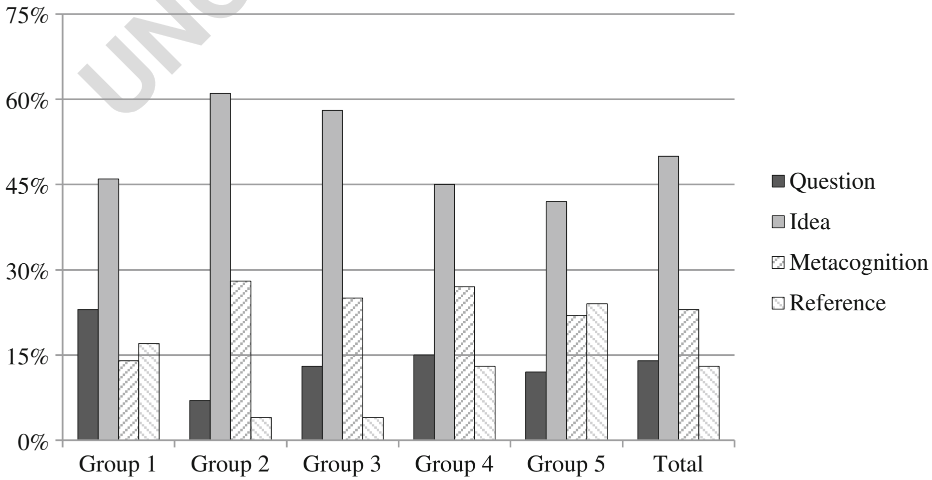

Fig. 1 Percentage of notes classified as having questions, ideas, metacognition, and reference during small group collaboration

Discourse patterns and development in inquiry threads

The students created 23 discussion threads during the 8-week fixed group collaboration period. Groups 1, 2 and 5 each created five inquiry threads, while Groups 3 and 4 each created four. The threads covered concepts relating to research methods, including research questions, variables, sampling, interviews and questionnaires. All inquiry threads were evaluated in terms of the discourse patterns identified by van Aalst (2009); the results are shown in Table 4.

Of the 23 threads, 18 were classified as knowledge sharing and five as knowledge construction; no thread was identified as knowledge creation. Two out of four threads in Group 4, and two out of five in Group 1, revealed knowledge construction, while the others were identified as knowledge sharing patterns. For Group 2, only one of the five threads revealed knowledge construction; no Group 3 or 5 thread revealed any knowledge construction.

All of the notes were reordered following the contribution timeline for each inquiry thread. We then divided the notes in each thread into two periods with equal numbers of notes. The levels of questions and ideas in the discourse threads across these two periods were then rated on a four-point scale (Table 5), following the measures used by Zhang et al. (2007), to identify collective knowledge development. Those groups (1 and 4) with high proportions of knowledge construction threads generated higher quality questions and ideas. The levels of ideas generated in each group were relatively consistent with the level of the questions posted in their respective group discourses. A slight increase was observed in the second halves of the threads in Groups 1, 4 and 5, for both questions and ideas.

Groups 1 and 2 exhibited the same social interaction patterns, but differed substantially from previous analyses in terms of knowledge distribution, and so were examined more closely. Group 1 contributed a total of 20 questions and 41 ideas, while Group 2 contributed five questions and 37 ideas. On average, there were 16.4 (*SD*=12.9) and 13.4 (*SD*=6.2) notes in each thread for Groups 1 and 2, respectively. Group 1 appeared to be more productive than Group 2, as the former focused on knowledge construction discourse, while the latter concentrated more on knowledge sharing discourse. As shown in Table 5, Group 1 generated relatively higher levels of questions and ideas than Group 2, although there were few differences between the groups in terms of gains in the quality of questions and ideas over time. Apart from differences in the number of contributions, the generation of high quality questions and ideas might be one reason why Group 1 exhibited more knowledge construction patterns than did Group 2. No statistical test was conducted, due to the small sample size (n=5).

Collaboration patterns during opportunistic collaboration

As mentioned above, in the last 8 weeks of the course, students were not assigned to groups, but contributed to a shared, class-level Knowledge Forum view. One assumption of the instructional design was that students who were inexperienced in online discussions might initially find it difficult to keep track of contributions from many participants, but that this

Table 4 Descriptive analysis of the inquiry threads in the fixed groups

	Group 1	Group 2	Group 3	Group 4	Group 5	Total
Knowledge sharing threads	3	4	4	2	5	18
Knowledge construction threads	2	1	0	2	0	5
Total	5	5	4	4	5	23

Table 5 Mean levels of questions and ideas for threads in fixed groups (with standard deviations in parentheses)

	Question		Idea	
	First half of threads	Second half of threads	First half of threads	Second half of threads
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)
Group 3	2.0 (0.0)	2.0 (0.0)	2.1 (0.4)	2.3 (0.6)
Group 4	2.6 (0.5)	3.0 (1.3)	2.5 (0.7)	2.7 (0.7)
Group 5	1.8 (0.5)	2.5 (0.9)	2.1 (0.8)	2.3 (0.6)

would improve after their initial experiences in fixed group collaboration. In this section, we present similar analyses for Phase 2 of the course (opportunistic collaboration) and compare results with those of Phase 1.

Structure of social networks

Table 6 shows the social network analysis results for opportunistic collaboration and compares them to the overall group averages from the fixed groups phase. Not surprisingly, the note reading density (68.0 %) of fixed group collaborators at the whole class level was much lower than the values measured separately for the five small groups (100 %). The rates of note reading and responding densities also increased with the change of social configuration, from 68 % for fixed group collaboration to 90.3 % for opportunistic collaboration. This indicates that, in Phase 2, class level interactivity spread to more participants. Simultaneously, the betweenness centralization of the social collaborative network was calculated for both note reading and note responding activities. The decreasing trend in this indicator implies that opportunistic collaboration led to broader collaboration, resulting in a relatively distributed and even social network in the class community (Table 7). Q8

Clique analysis was also performed to identify any sub-network that emerged through responsive interactions. It was found that the number of cliques increased substantially, from 8

Table 6 Patterns of social networks in the two types of social configurations

	Phase 1: Fixed group collaboration	Phase 2: Opportunistic collaboration
No. of notes	12.9 (3.8)	12.0 (4.9)
% of notes read	17.8 (9.4)	36.8 (18.4)
No. of note responses	10.1 (5.6)	10.6 (5.0)
Density of note reading	68.0 %	90.3 %
Density of note responding	16.6 %	21.9 %
Betweenness centralization of collaborative network	4.4 %	0.2 %
No. of cliques	8	36
Clique size	4.4 (0.5)	2.6 (0.5)
Each student belongs to cliques	1.2 (0.4)	4.7 (4.6)

Table 7 Descriptive analysis of the inquiry threads in the two types of social configurations (with standard deviations in parentheses)

	Total no. of threads	Mean length of threads	No. of knowledge sharing threads	No. of knowledge construction threads
Fixed group collaboration	23	14.5 (8.3)	18	5
Opportunistic collaboration	10	30.0 (22.1)	5	5
Whole course	33	19.2 (15.4)	23	10

to 36, following the shift from fixed groups to opportunistic collaboration at the class level. There was, however, a slight decrease in clique sizes from 4.38 (*SD*=0.52) to 3.56 (*SD*=0.50) across the two phases. On average, each student belonged to 1.23 cliques (*SD*=0.43) in the fixed group collaborations, and to 4.65 cliques (*SD*=4.64) in the opportunistic collaboration, demonstrating a significant change between the two phases (t (25)=3.73, p<.01). These results suggest that opportunistic collaboration enabled the students to collaborate continuously with new and more sub-networks, all of whose members were fully inter-connected (density= 100 %), and therefore increased the likelihood of knowledge being disseminated between the different participants. However, the decrease in clique sizes might indicate relatively scattered discourse during opportunistic collaboration.

Questioning, ideation, metacognition, and referencing

Figure 2 shows the results for the content analysis of the opportunistic collaboration phase and compares them with the aggregate results for the fixed groups phase (i.e., the extreme right set of bars in Fig. 1).

A Chi-square analysis shows that the two phases were statistically different from each other in terms of knowledge distributions (χ^2 (df=3, 651)=42.9, p<.001). During the opportunistic phase, relatively more notes contained ideas, but fewer notes contained metacognitive contributions. As metacognition is a very important feature of CSCL, this points to a potential limitation of opportunistic collaboration. The level of questioning in the two phases was

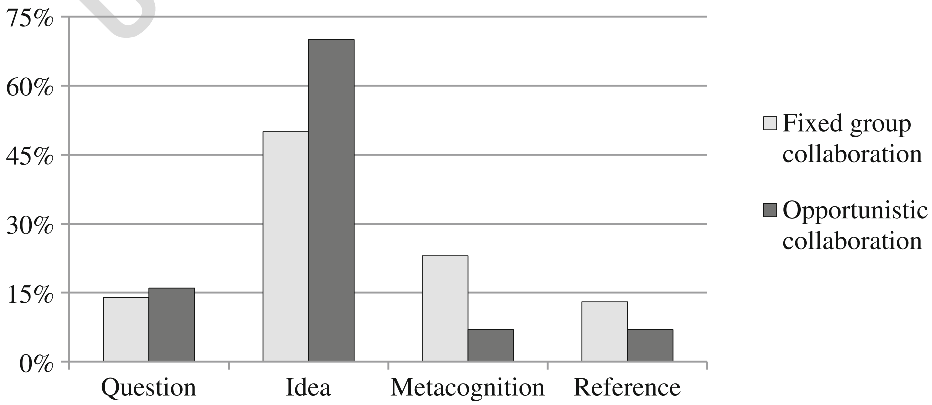

Fig. 2 Percentage of notes classified as having questions, ideas, metacognition, and reference in fixed groups and opportunistic collaboration

similar, but still rather low compared with other studies involving Knowledge Forum (e.g. van Aalst and Chan 2007; Zhang et al. 2007).

Discourse patterns and development in inquiry threads

For the opportunistic collaboration phase, ten inquiry threads were identified; five were classified as knowledge sharing and five as knowledge construction. This compares favorably with the fixed groups phase, during which there were 23 inquiry threads, but only five classified as knowledge construction. As Table 6 shows, the average inquiry thread during the opportunistic collaboration phase had twice as many notes as during the fixed groups phase, which may also explain the greater evidence of knowledge construction. There were no knowledge creation threads in either phase, a possible explanation for which is that knowledge creation needs to be developed over a longer period of online discourse, and may need more instructional support than previously thought.

Table 8 shows the analysis results of the levels of questions and ideas found in the inquiry threads in the opportunistic collaboration phase, and compares them to the results from the fixed groups phase. As the table shows, the level of *questions* and *ideas* improved very slightly from the first half of the thread to the second, for both fixed groups and opportunistic collaborations. The level of questions and ideas during the opportunistic collaboration phase was generally higher than during the fixed groups phase, but this could be partly because the students engaged in opportunistic collaboration after completing the fixed group experience. No statistical test was performed due to the limited number of threads (n=5).

Domain knowledge at the end of the course

We also examined possible relationships between online discourse and individual gains, as measured by assessment tasks. Students' conceptual understanding scores averaged 3.1 (SD=1.3) for the content knowledge discussed in fixed groups, and 3.3 (SD=0.9) for topics discussed in opportunistic collaboration. To simplify the analysis, indices such as note creation, note reading and note responding contributions were combined as the variable, *participation*, by calculating the sum of Z-scores. SNA measures of betweenness centrality for each participant's note reading and note responding interactions were combined as the variable, *social network centrality*. The results of correlation analyses for Phase 1 and 2 are similar (see Table 9), with individual conceptual understanding scores being significantly correlated to variables about *participation* and number of *high-level ideas*. In other words, students were more likely to have a better understanding about domain knowledge when they were involved in active participation and contributed high-level ideas during online discourse.

Table 8 Mean levels of questions and ideas for thread in the two types of social configurations (with standard deviations in parentheses)

	Fixed group collaboration		Opportunistic collaboration	
	Question	Idea	Question	Idea
First half of threads	2.3 (0.9)	2.4 (1.1)	2.6 (0.8)	2.6 (0.7)
Second half of threads	2.5 (1.1)	2.5 (0.9)	2.7 (1.0)	2.8 (0.8)

Table 9 Phase 1 and Phase 2 correlation analyses of participation, social network centrality, high-level questions, and high-level ideas with individuals' domain understanding (*n*=26)

	1	2	3	4
Phase 1: fixed group collaboration				
1. Participation	–			
2. Social network centrality	.61**	–		
3. High-level questions	.44*	.08	–	
4. High-level ideas	.65***	.12	.37	
5. Domain knowledge understanding	.45*	.26	.20	.41*
Phase 2: opportunistic collaboration				
1. Participation	–			
2. Social network centrality	.70**	–		
3. High level-questions	.43*	.12	–	
4. High level-ideas	.66***	.22	.19	–
5. Domain knowledge understanding	.55**	.42*	.32	.45*

* $p<.05$;** $p<.01$; ***$p<.001$

Discussion

In online discourse, fixed groups are normally formed within class and before collaboration, while opportunistic collaboration enables groups to be formed in a more emergent and flexible way. Both are important in current CSCL studies; the former often bridges learning in individuals and learning in a class community (Stahl 2013b), while the latter is closer to improvisational and emergent collaboration in real life (Sawyer 2003). The current study has explored how students collaborated in two modes of online discourse—fixed groups and opportunistic collaboration—as an integral part of a regular Chinese undergraduate course. The examination focused primarily on patterns of social interaction; characteristics of knowledge distributed through collaboration; discourse patterns; and, advances in knowledge that emerged from discourse threads.

Promise and constraints of fixed groups and opportunistic collaboration

Within and across group comparison during the phase of fixed group collaboration revealed that all five groups showed intensive, decentralized reading and responding interactions, but differed substantially in their contributions to four categories of knowledge: *question*, *idea*, *metacognition*, and *reference*. Groups productive in constructive discourse tended to generate higher level questions and ideas, suggesting that intensive social interaction may not guarantee productive cognitive processing.

An examination of opportunistic collaboration showed that social interactivity increased when students were exposed to class-wide discussions, and led to relatively equal interactions among students, which is compatible with previous findings (Zhang et al. 2009). At the same time, opportunistic collaboration resulted in a greater number and level of ideas, and more constructive discourse, than was found in fixed groups. However, clique analysis results indicated relatively scattered interactions in opportunistic collaboration, suggesting that participants still encountered some constraints to engaging in productive discourse during opportunistic collaboration, although positive developmental trends emerged through the combination of two social configurations in this single course. In particular, we found that students contributed very few notes related to metacognition in the latter phase. One possible explanation for this might be that, during earlier collaborations within fixed groups, students internalized metacognition to guide their own discourse, while continual changes in group members during the latter opportunistic collaboration phase may have reduced students' sense of group belonging and led them to pay less attention to co-regulation. According to the literature, metacognition is crucial to promoting online discourse (De Jong 2006; Hadwin and Oshige 2011) and is activated only when learners are encouraged to become involved in it (Lin 2001). We recommend that some technical functions, such as highlighting important notes and charting participants' collective or individual progress, may be helpful in raising awareness of social metacognition, and in avoiding scattered interactions.

The present study also found some common constraints to online discourse in the two social configurations. First, these students contributed relatively fewer questions than those in other studies (van Aalst and Chan 2007; Zhang et al. 2007), so more specific pedagogical strategies may be required to help Chinese undergraduates pose more questions for sustaining their inquiries. Second, it was noteworthy that, while most of the knowledge produced by the students referred to ideas, the level of ideas did not change greatly over the course of the discussion threads in either phase, which is inconsistent with previous research findings (Zhang et al. 2007). The students might have encountered difficulties in collectively improving ideas, or the discourse itself may have encompassed the interplay between different levels of knowledge, and the development of ideas among students was slower than expected. It should be noted that knowledge construction might not follow a strictly linear process (Paavola et al. 2004; Wise and Chiu 2011), so the emergence of low-level knowledge is not necessarily negative. Third, contributing high level questions and ideas and longer threads are particularly beneficial to constructive discourse. Our analysis of the associations between online discourse and individuals' assessment task scores further indicated that strong participation and high-level ideas are positively related to gains in domain understanding. However, no thread was identified as knowledge creation discourse in this study. According to the literature, knowledge creation requires metadiscourse and a progression from initial understanding to the generation of new theory or knowledge products, which may require more time and cognitive efforts to emerge (Bereiter 2002; van Aalst 2009).

Limitations of the study

The study has several limitations. First, it was impossible to compare data from another class, as only one section of the course is taught annually. This reduces our confidence in the causal claims. Second, a major challenge of using the individual student as the analytical unit for content analysis is that the different units of content are, in fact, not independent; multi-level analysis has been recommended to address this issue (Cress 2008; De Wever et al. 2007), but the number of groups possible in classroom studies is often too small for its application. Also, the participants in this study were not selected randomly and the overall sample size was small. Further research using a larger, randomized sample base, in a different research context, would be of benefit and could clarify the learning effects associated with different types of social configuration. Also, a multi-level analysis could be used to explore the embedded structure of online discourse and the potential interactions and effects of combinations of fixed groups and opportunistic collaborations. Finally, the current study has relied exclusively on quantitative measures to explore the processes and dynamics of online discourse; it would be valuable to use mixed methods in further studies, as this would help reveal how and why groups emerge dynamically in opportunistic collaboration, and how individual students benefit from and contribute to online discourse, both quantitatively and qualitatively.

Conclusion

To conclude, this case study contributes to the CSCL literature by providing quantitative, multi-faceted analyses of online discourse in fixed groups and opportunistic collaborations. The findings enrich CSCL theory in terms of how students function as a group or a class community to mediate learning, and explore the possible synergetic impacts of combining two social configurations in a single course. The study also has theoretical value for understanding online discourse and for establishing a linkage between the process of online discourse, the nature of collaboration, and individual gains, which has practical implications for teachers and researchers designing CSCL environments, or providing instructional support to promote online discourse in authentic classrooms .

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