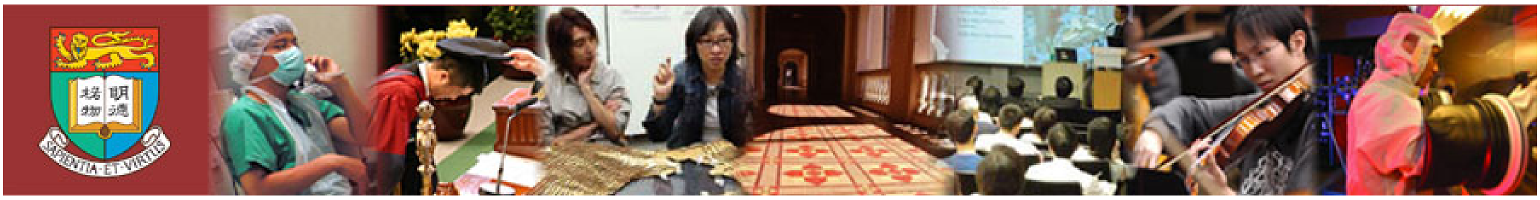

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Questioning and the Quality of Knowledge Constructed in a CSCL Context: A Study on Two Grade-levels of Students

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ABSTRACT

This paper aims to study the relationship between questioning and the quality of knowledge constructed in a CSCL context. In previous studies, different units of analysis are employed and the patterns of relationships are not consistent for different age groups. The analytic units of a thread, an individual, and a group are employed in this study, and two grades of students (grade 6 and grade 10) are investigated. At the thread level, we aim to examine to what extent questioning can be a mechanism for knowledge advancement, and we find that the tenth-graders are capable to advance knowledge through questioning, while for the sixth-graders, more facilitation seems to be needed. At the individual level, we find that for the sixth-graders, those asking good questions are likely to express high-level explanations, suggesting that individual competence plays an important role in advancing knowledge among these younger students. For the tenth-graders, a "division of labor" is observed that good questions are generated by some students while high-level explanations by others. At the group level, a high and positive correlation is found for both grades. The findings suggest further research is needed to examine other possible mechanisms for knowledge advancement in online collaborative discourse.

Keywords: CSCL, Questioning, Knowledge building

INTRODUCTION

The relationship between questioning and inquiry is a theme that has attracted much attention since the time of the ancient Greeks. *Meno* contains many examples of how Socrates used questions to help others seek knowledge. Aristotle suggests that the kinds of questions we ask are directly related to the knowledge we can get. In the context of computer-supported collaborative learning (CSCL), questioning is often considered as an important mechanism for students to advance their knowledge through technology-mediated collaborative inquiry (Hakkarainen, 2003; Scardamalia & Bereiter, 1991). Knowledge building as a pedagogical approach emphasizes students' collective responsibility for the advancement of the community's knowledge (Bereiter, 2002; Scardamalia, 2002), and the generation of questions to advance inquiry and understanding is considered an important demonstration of the learner's epistemic agency. There is an emphasis on the quality of questions, particularly in differentiating fact-seeking from explanation-seeking questions, with a view that the latter is more contributive to advancing knowledge (e.g., Hakkarainen, 2003; Lee, Chan & van Aalst, 2006; Zhang, Scardamalia, Lamon, Messina & Reeve, 2007). However, is the quality of questions asked necessarily related to the quality of the knowledge ideas constructed in a CSCL discourse? In addition to using case studies to illustrate how students might deepen their inquiry by generating a series of questions (e.g., Hakkarainen, 2003), correlation analyses have also been used to explore the relationship between the level of questions and the quality of knowledge constructed. Different units of analysis have been employed to address this relationship in previous studies, at individual (e.g., Hakkarainen, Lipponen, & Jarvela, 2002), group (e.g., King, 1994; Webb, 1989), and thread (e.g., Chen & Jiang, 2004; Lai & Law, 2011) levels. However, the correlation patterns reported were not consistent and appear to be different for different age groups (Hakkarainen et al., 2002; Lee et al., 2006). In this paper, we argue that different units of analysis address different research questions, all of which are relevant in the context of CSCL. A thread-level analysis helps us understand how knowledge advances and to what extent questioning can be a mechanism for collective knowledge advancement. A group-level analysis helps us understand the relationship between a group's questioning engagement and its overall quality of knowledge co-constructed. An individual-level analysis helps us understand the role played by individual competences in the process of knowledge building and whether the knowledge advancement made is limited to a small number of students. By analyzing the relationship between the level of questions and the quality of knowledge constructed for the same set of CSCL discourse for all three units of analysis, this paper seeks to gain a deeper understanding of the role of questioning in knowledge advancement in a CSCL context. Two sets of discourse data generated by two age groups of students are examined in this study to explore whether the relationships differ for the different age groups.

LITERATURE REVIEW

In traditional classrooms, questions are usually asked by teachers. The initiation-response-evaluation (IRE, Mehan, 1979) structure depicts the patterns often found in classroom discourse in which the teacher initiates a question, the students respond, and then the teacher evaluates the responses. The number of questions students ask in classroom settings is low (Graesser & Person, 1994). On the other hand, there are studies reporting that students' self-generated questions can facilitate learning, including text comprehension and conceptual understanding (e.g., Chin, Brown & Bruce, 2002; King, 1990; Palincsar & Brown, 1984), and that even elementary students are capable of generating questions of high quality (Hakkarainen, 2003; Scardamalia & Bereiter, 1991). Questions help students to identify their current understanding of a subject, to relate different ideas, and to articulate the knowledge gap for further inquiry (Chin & Osborne, 2008). Further, through suitable instructional design, the quality of students' questions can be enhanced (e.g., Cuccio-Schirripa & Steiner, 2000; Hartford & Good, 1982; King & Rosenshine, 1993). In studies that examine the relationships between students' questions and learning outcomes, it is found that students' conceptual understanding and achievement level are generally related to the quality rather than the quantity of questions asked (e.g., Tisher, 1977; Harper, Etkina & Lin, 2003). In inquiry-based and collaborative learning contexts, students are more likely to generate questions of higher quality (e.g., Hofstein, Shore & Kipnis, 2004; Marbach-Ad & Sokolove, 2000). In recent literature, pedagogical models that emphasize students' collaborative inquiry, e.g. knowledge building pedagogy, often consider students' self-generated questions to be important resources upon which students can advance their inquiry (Chin et al., 2002; Hakkarainen, 2003; Scardamalia & Bereiter, 1991).

Knowledge Building Pedagogy

Knowledge building as a pedagogical approach emphasizes students' collective responsibility for the advancement of the community's knowledge (Scardamalia, 2002; Scardamalia & Bereiter, 2006). Its implementation in schools is usually integrated with an asynchronous online platform, Knowledge Forum® (KF in short), which is specifically designed as an environment for students to make their ideas explicit so that everyone can contribute to the continual improvement of ideas and knowledge building (Scardamalia, 2002). Student's self-generated questions are considered especially important in knowledge building as it emphasizes the epistemic agency of students (Scardamalia, 2002; Zhang et al., 2007). In the literature on knowledge building, one widely employed classification of students' questions is based on their epistemological nature—whether the questions target factual or explanatory knowledge. Questions seeking explanations are considered more productive from the perspective of knowledge building as their answers contribute to a deeper level of understanding compared to fact-seeking ones (Hakkarainen, 2003; Lee et al., 2006; Zhang et al., 2007). In addition to the questions asked, students can articulate their "knowledge ideas" (Hakkarainen, 2003) in the process of inquiry, which can be responses to questions, intuitive theories, and scientific information. Based on these knowledge ideas, students can generate further questions so that their inquiry can be carried forward (Hakarainen, 2003; Hakkarainen & Sintonen, 2002). Hence, during the course of inquiry, there will be a number of questions as well as knowledge ideas generated by students. In the literature on knowledge building, the quality of knowledge ideas are frequently categorized according to their "levels of explanation" (e.g., Hakkaranen, 2003; Lee et al., 2006; Zhang et al., 2007). The rationale is again based on the epistemological nature of knowledge, as explanation is more illustrative of deep understanding than factual knowledge (Carey & Smith, 1993). Factual knowledge can be referred to as the description of terms, phenomena, and experiences, while explanation as mechanisms and relationships (Zhang et al., 2007).

Questioning and the Quality of Knowledge Ideas

Both students' questions and the knowledge ideas they express are important elements in the process of collaborative inquiry, as questions may stimulate the articulation of knowledge ideas, and the articulation of knowledge ideas may lead to further research questions. Through continuous iterations of these cycles, students' collective knowledge can be advanced. Case studies have been reported to describe how elementary students can engage in these iterative cycles to advance their inquiry (Hakkarainen, 2003; Zhang et al., 2007). These case studies are valuable in illustrating how students may deepen their inquiry by questioning and putting forward knowledge ideas. On the other hand, it is not clear from the literature that the articulation of better questions in a collaborative discourse will necessarily stimulate higher quality knowledge ideas being expressed in the ensuing discussions. For example, there could be cases that good questions posted in a discussion do not result in any knowledge advancement, as they may not be responded to at all. Correlation analysis based on entire data sets may provide a more cogent way of investigating the relationship between levels of questions and levels of explanations. However, correlation analyses conducted using different analytic units carry different meanings. It is necessary to specify an appropriate analytic unit depending on the specific research questions targeted.

An Individual as the Analytic Unit

In studies that examine the relationship between questioning and the quality of knowledge constructed, an individual is popularly employed as the unit of analysis (e.g., Hakkarainen et al., 2002; Lee et al., 2006). Hakkarainen et al. (2002) analyzed the relationship among three classrooms of fourth-grade and fifth-grade students, and found a positive correlation when the unit of analysis adopted was a student. The positive correlation indicates that at the individual behavioral level, students who generate a higher proportion of explanation-seeking questions in an online discussion are proportionately more likely to contribute higher quality knowledge ideas in terms of their levels of explanation. Employing an individual as the analytic unit has the advantage that other individual-level variables, such as the academic result of a student, can be taken into consideration at the same time. For example, with a sample of ninth-grade students, Lee et al. (2006) analyzed the correlation patterns among a number of variables, including the level of questions based on the differentiation between orientations towards facts and explanations, the level of explanations of knowledge ideas, academic achievement, score of a portfolio note written by each student, and indicators of participation; all the variables were measured at the level of a student. The correlation between the quality of questions and the quality of knowledge ideas reported in Lee et al.'s (2006) study was not significant. However, as the major research problem addressed in Lee et al.'s study is the roles of knowledge building portfolios in scaffolding students' collaborative inquiry, the quality of questions and quality of knowledge ideas were employed as separate indicators of students' performances. The paper does not report details about the lack of correlation nor compare its findings with Hakkarainen et al.'s (2002) mentioned above.

A correlation between the quality of questions and quality of knowledge ideas contributed at an individual level does not reflect whether knowledge advancement in a knowledge building discourse is more likely to be associated with high quality questions since knowledge building takes place at the community level. A high correlation may even suggest that high-quality questions and knowledge ideas are contributed by the same students, which may not be indicative of the knowledge advancement of the community. On the other hand, the identification of correlation between the two constructs would suggest that individual competences play a role in the process of knowledge building. In the literature, it is reported that even young students can engage in productive knowledge building activities (Scardamalia, 2002), hence suggesting that individual competences may not be a determining factor influencing knowledge building engagement. As contributions to good questions and high-level explanations are two important indicators for knowledge building engagement, studying their correlation at the individual level could offer insights on whether individual competences might also play a role in the process of knowledge building. Moreover, the contradictory findings reported in the studies of Hakkarainen et al. (2002) and Lee et al. (2006) warrant further research to find out whether this difference is indicative of random relationships, or whether there is a regular pattern that can be consistently found between primary and secondary level students.

A Group as the Analytic Unit

A group is another analytic unit that we have adopted for our analyses presented in this paper. A group often serves as an organizational unit adopted by teachers for their students to conduct inquiries, and this is certainly the case for the teacher involved in this study. As argued by Stahl (2005), analyzing the discourse of small groups can offer insight on how learning is achieved in CSCL settings. In the literature on knowledge building, there are studies that focus on a group as the analytic unit (e.g., Law & Wong, 2003; van Aalst, 2009). van Aalst (2009) reports on the analysis of the online discourse of a total of four groups, and finds that the group with the highest proportion of explanation-seeking questions was also the one with the highest proportion of explanation-oriented ideas expressed. Although only four groups were analyzed in van Aalst's (2009) study, the finding is consistent with those reported in the literature on collaborative learning—that groups asking low-level questions targeting at facts are also more likely to construct knowledge characterized by simple statements of facts or information, while groups asking high-level questions targeting at explanations, inferences and connections between ideas are also more likely to construct high-quality knowledge characterized by explanations, inferences, and connected ideas (e.g., King, 1994; King & Rosenshine, 1993).

Using a group as the analytic unit, the correlation reflects the relationship at the collective level, which is justifiable since knowledge building is considered as a collective rather than an individual achievement (Bereiter, 2002; Scardamalia, 2002). However, a group is not the only collective unit of analysis that can be found in the literature on CSCL. A thread is another possible analytic unit, as reviewed in the following section. Further, by comparing analysis at the individual and group levels, we can explore further the interactions between individual behavior and group behavior with regard to questioning and knowledge idea construction.

A Thread as the Analytic Unit

While a group can serve as a collective analytic unit, it is not the only collective unit of analysis found in the literature on CSCL. A thread is another meaningful unit of analysis. While a group is an organizational unit to structure group collaboration, a thread registers discussions around a theme, and is often the location where collective knowledge advancement can be most easily traced. In CSCL contexts, students often participate in multiple threads in their process of inquiry into different problems of understanding. Within a thread, students can generate research questions and articulate knowledge ideas, which can lead to further research questions and further articulation of knowledge ideas (Hakkarainen, 2003; Hakkarainen & Sintonen, 2002). In the literature on CSCL, there are studies employing a thread as the unit of analysis (e.g., Chen & Jiang, 2004; Clark & Sampson, 2007). While group-level analysis takes into consideration the overall performance of a group, it does not reflect the dynamic relationships between questioning and the quality of knowledge ideas constructed as a CSCL discourse unfolds. Analysis at a thread level can examine whether the quality of questions asked in a thread is related to the quality of knowledge subsequently constructed within the same thread. Based on the emphasis on the role of questioning in knowledge building theory, a positive correlation might be expected. As there have not yet been reports on studies that examine such a relationship using a thread as the analytic unit within a discourse, we still lack empirical evidence that there is a necessary dynamic relationship between the quality of questions asked and the quality of the knowledge constructed as students conduct their inquiry in threads. Moreover, although it is reported that young students can engage in knowledge building (Scardamalia, 2002), it is not clear whether the mechanisms for knowledge advancement is different or the same for different age groups of students.

Research Questions

The above review suggests that the relationship between the level of questions and the quality of knowledge constructed is not straightforward as this can be explored at different levels and the correlation patterns might also be different for different age groups. Thread level analysis, which is less studied in the literature, is particularly important if the research focus is on how knowledge is advanced dynamically through collaborative discourse. The level of an individual could shed light on the role played by individual competences in the process of knowledge building and whether the knowledge advancement made is limited to a small number of students. Group level analysis could provide information on the overall performance of a group in terms of their engagement in knowledge building.

Summarizing the above, there are two fundamental problems arising from the literature on the relationship between questioning and knowledge building. The first relates to the role of individual competence in knowledge building, which has not been investigated but should not be discounted. The second relates to the relationship between the quality of questions and the quality of the knowledge ideas constructed through the ensuing discourse, in particular, whether high level questions are necessary or sufficient for the construction of higher level knowledge ideas. In order to address these two problems, four specific research questions are investigated in this study for two different age cohorts of students:

1. Is there a relationship between the level of questions and the quality of knowledge constructed in a thread?
2. Is there a relationship between the level of questions and the quality of knowledge constructed at the level of an individual and how do individual competences contribute to the knowledge advancement made?
3. Is there a relationship between the level of questions and the quality of knowledge constructed at the level of a group and how is the correlation pattern related to those at the levels of a thread and an individual?
4. Are there any grade level differences on the above correlation patterns observed?

METHOD

The Research Context

The data analyzed in this study come from the "Learning Community Project" (LCP) led by the Center for Information Technology in Education (CITE) of the University of Hong

Kong. The goal of LCP is to promote knowledge building as a pedagogical approach in primary and secondary schools in Hong Kong. The online discussion platform, Knowledge Forum® (KF in short), is used in this project as an integral part of the knowledge building environment. LCP provides professional development for teachers and technical training and support for teachers and students. Each year since its launch in 2001, separate "databases" are created for primary and secondary school students and teachers to conduct their inquiries on KF. In this study, a "dataset" refers to the online discourse of one school; it may include several classes each with several inquiry groups discussing on KF during a certain period. In order to investigate whether the relationship between levels of questions and levels of explanation may be different for different age groups, a total of two datasets, one primary (sixth-grade) and one secondary (tenth-grade), are included in this study. Previous studies suggest that a long period of inquiry is needed for productive knowledge building discourse to emerge (e.g., Zhang et al., 2007). The two selected datasets had the longest period of inquiry among all databases in the LCP project at the time the analysis was conducted, each spanning a period of about six weeks for the online inquiry.

The Online Discussion Platform

Knowledge Forum® (KF), the online discussion platform adopted in LCP, was specifically designed to support the socio-metacognitive dynamics described in the twelve knowledge building principles (Scardamalia, 2002). On KF, students can express their ideas by writing discussion notes. Once a note is contributed, it can become an object for everyone to build onto for further idea improvement. In writing a discussion note, meta-cognitive prompts or scaffolds such as “New information”, “New idea”, “I need to understand”, and “My theory” may be used to identify the epistemological nature of the contribution contained in the note. Notes and their build-on notes are linked together in a thread. On the computer screen, each build-on relationship is represented graphically by a straight line, hence the thread structure of notes can be clearly visualized.

Participants and the Pedagogical Contexts

The Sixth-Grade Students

The online discourse data of three classes (6A, 6B, and 6C) of sixth-grade students (N=86) in the same school were collected. In each of the classes, five inquiry groups were formed, each working on one problem through discussions on KF, resulting in a total of 15 groups, each consisting of about six students. The students were relatively new to knowledge building pedagogy. However, about a quarter of the students across the three classes had taken part in knowledge building activities using KF in an international collaboration in the previous year, in which they collaborated with a class of students of the same grade in a different country to inquire about topics related to ancient civilizations. The other three-quarters of students were totally new to this approach. The groups were organized so that each group had at least one “seed” student who had used KF in the previous year so that he/she could offer technical support to the other group members.

The knowledge building activities of the sixth-grade students were carried out in the context of the school subject “General Studies”. The three classes were taught by two teachers. The teacher who taught two of the classes was the one who had initiated the adoption of knowledge building in the school, and had participated in the international collaboration the previous year. The other teacher was new to this approach, but had participated in a workshop on knowledge building organized by the LCP. These two teachers decided on a seed question and a list of problems for students to focus their inquiry on. The seed question was “Can technology solve the problem of ______?” and the problem could be: “Global Warming”, “Energy Crisis”, “Species Extinction”, etc. Students formed groups to inquire about the topic they were interested in. During the inquiry period, there were three 50-minute “General Studies” lessons per week, all of which were held in the Computer Lab, where students could have access to KF. The first ten minutes of a lesson was usually spent on a brief reporting of progress from each group, group sharing, showcase of good notes, and the introduction of important knowledge building principles. Students could write their notes in class, but they were also encouraged to work on the inquiry during recess time and outside of school hours. The two teachers wrote only two notes with the seed question on KF. Thus, almost all of the notes were written by students.

The Tenth-Grade Students

The online discourse data of the tenth-grade students were from two classes, each with 40 students who were new to participating in online knowledge building activities. The two classes were taught by the same Chemistry teacher, who was also new to knowledge building, but had attended seminars and participated in workshops organized by the LCP. He identified relevant topics in Chemistry for students to choose for their inquiry.

As the students were new to knowledge building, staff from the LCP went to their school to teach them how to use KF to build knowledge collaboratively through online discussions. The teacher did not write any notes on KF, so all the notes were written by the students while carrying out their inquiry. Unlike the sixth-grade students who formed groups only with students within the same class, the tenth-grade students were allowed to form groups with students in the other classes. A total of twelve groups, with group sizes ranging from six to nine students, were formed to study the topics of "Chemistry and the Quality of Water" (Water Quality), "Batteries as Stored Energy" (Batteries), "Man-made Fiber and Plastics" (Plastics), and "The Chemistry of an Ideal Vehicle" (Ideal Vehicle).

Data Analysis

The discussion notes from both datasets are systematically coded on two aspects. First, each note is examined to identify the questions asked by the students, which are then classified according to their epistemological nature. Each note is also coded for the knowledge ideas they contain, which may be answers to questions, intuitive ideas, scientific theories, or information gathered, and the classification is according to their levels of explanation.

Epistemological Nature of Students' Questions (Levels of Questions)

Although different classification frameworks of questions have been developed by different researchers (e.g., Dillon, 1984; Graesser and Person, 1994), the epistemological nature of a student's question—whether it is "explanation-seeking" or "fact-seeking"—is a widely used coding scheme for assessing the level of engagement in knowledge building (e.g., Hakkarainen, 2003; Zhang et al., 2007), and is adopted for analyzing question quality in this study. In addition to these two categories of questions (explanation-seeking and fact-seeking), simple clarification questions were also found in the online discourse data. Thus, a third category, "simple clarification", is included in the coding (the same three-category coding of questions was also employed in a recent study on knowledge building by van Aalst (2009)). In the following sections, this coding scheme will be referred to as the “level of questions” coding. Examples of questions at these three levels of are shown in Table 1.

Table 1. Examples of the three levels of questions generated by students

Levels of Questions	Examples
Explanation-seeking	“*How UV (ultra violet) works to improve water quality?*”
Fact-seeking	“*Which country is using solar energy to move the car?*”
Simple clarification	“*Can you put up some picture, to let us know what red panda looks like?*”

Levels of Explanation of Student's Knowledge Ideas

In parallel to the classification of levels of questions, students’ non-question-asking contributions are analyzed according to their levels of explanation (Hakkarainen, 2003; Zhang et al., 2007). The analysis involves two steps: 1) whether a knowledge idea was articulated in a note; and 2) if a knowledge idea was articulated, what its level of explanation was. To be qualified as a “knowledge idea”, knowledge content has to be present in a note. For example, in some notes, a student might simply write, “*I agree*”, with no knowledge idea being expressed. Notes containing copy and paste contents or simply a URL for a web-site are also considered as not expressing any knowledge ideas. For notes with knowledge ideas expressed, the coding scheme used by Zhang et al.’s (2007) is adopted to classify these notes into a total of four levels of explanation: 1) unelaborated facts; 2) elaborated facts; 3) unelaborated explanations; and 4) elaborated explanations. Facts focus on descriptions of terms, phenomena and experience, while explanations on mechanisms and relationships (Zhang et al., 2007). To code the data, the whole note is studied to identify whether the focus was on gathering factual information or on the construction of explanations, and whether the knowledge idea was elaborated or unelaborated. Presented in Table 2 are examples of each of the four categories taken from this study:

Table 2. Examples of the four categories of levels of explanation

Categories	Examples
Elaborated Explanation	"*UV (Ultra Violet) is a light wave which has more energy than the visible light. Its wave length is shorter so that every time it contains more energy. This energy can change the nature of the bacteria so the bacteria die.*"
Unelaborated Explanation	"*UV (Ultra Violet) is a light. It is a kind of waves and it is not a matter. It does not remain in the water*."
Elaborated Fact	"*Fossil fuel is composed of three kinds of elements: gas, oil, or coal. Fossil fuel energy is a nonrenewable type of energy, that means, it would disappear if we use it all or if we waste it, we wouldn't get it again….*"
Unelaborated Fact	"*Geothermal energy is the natural heat extracted from the earth's crust.*"

Correlation Analyses with Different Units of Analysis

Following the procedures employed in Zhang et al.'s (2007) study, numerical values were assigned to each note on its level of explanation and/or level of questions where appropriate. "Unelaborated facts", "elaborated facts", "unelaborated explanations", and “elaborated explanations” were assigned with scores of “1”, “2”, “3”, and “4” respectively, indicating an increase in quality (Zhang et al., 2007). Similarly, questions classified as “simple clarification”, “fact-seeking”, and “explanation-seeking” were assigned with scores of “1”, “2”, and “3” respectively, indicating an increase in quality. The average level of explanations and average level of questions were calculated for each thread, each student, and each group respectively. Correlation analyses are then conducted for each of the three units of analysis respectively.

It should be noted that in conducting correlation analyses, the independence of observations is normally assumed (Stevens, 2009). However, in the CSCL context of the present study, students interact with one another, contributing questions and knowledge ideas to different threads, such independence of observation cannot be assumed. To correct for the increased possibility of errors resulting from the violation of this assumption, a more stringent level of statistical significance—an alpha level of .01—is employed in reporting the correlation results (see Stevens, 2009: p.219 for details).

Inter-coder Reliability

To investigate the reliability of the coding methods employed in this study, a total of 343 notes (12.1%) generated from the entire discussion of two sixth-grade and two tenth-grade groups, totaling 135 and 208 notes respectively, were classified by another coder.

Cohen’s (1960) kappa is employed as the measure for inter-coder reliability. According to Landis and Koch (1977), a negative value of Cohen’s kappa indicates that there is no agreement at all, a value between zero to .2 indicates a slight agreement, a value between .21 to .4 indicates a fair agreement, a value between .41 to .6 indicates a moderate agreement, a value between .61 to .8 indicates a substantial agreement, and a value between .81 and one indicates an almost perfect agreement. Of the 343 notes analyzed for inter-coder reliability, a total of 90 questions were identified, which comprised 11.9% of the total number of questions identified in this study. With respect to the classification of levels of questions, the Cohen’s kappa was .79. For the coding on levels of explanation, a total of 255 notes out of the 343 notes contained knowledge ideas, comprising 13.7% of the total number of notes coded for levels of explanation. The Cohen’s kappa for levels of explanation was .69.

RESULTS

A total of 1421 and 1419 notes, involving a total of 114 and 184 threads, were generated by the sixth-grade and the tenth-grade students respectively. The average thread lengths for the sixth-grade and tenth-grade students were 12.46 and 7.71 respectively.

Descriptive Analysis of the Levels of Questions and Levels of Explanations

A total of 282 and 477 questions were identified for the sixth-grade and tenth-grade students respectively. Although the tenth-graders tended to ask more questions than the sixth-graders, the percentages of questions identified as explanation-seeking for the two grades of students were similar, both around 40%, as seen in table 3. On the other hand, a much higher proportion of the questions asked by the sixth-grade students were categorized as simple clarification (30%) as compared to the tenth-grade students (12%). In contrast, the tenth-grade students asked more fact-seeking questions compared to the sixth-grade students.

Table 3. Numbers and percentages of questions in different levels of questions generated by the two grades of students

Grade		Levels of Questions			
		Simple Clarification	Fact-seeking	Explanation-seeking	Total
Sixth	Number	85	84	113	282
	%	30.1	29.8	40.1	100
Tenth	Number	59	215	203	477
	%	12.4	45.1	42.6	100

The discussion notes were also analyzed according to the levels of explanations of the knowledge ideas expressed. A total of 918 and 946 notes of the sixth-grade and tenth-grade students respectively were found to contain knowledge ideas, and the classification results are shown in Table 4. For both grades of students, slightly more than half of their notes with knowledge ideas were classified as unelaborated facts (Fact-Unelab.). The sixth-grade students had a total of 194 notes classified as explanatory, comprising 21.1% (16.1 + 5.0) of their notes with knowledge ideas. For the sixth-grade students, 252 notes, comprising 26.7% (19.9 + 6.8) of those notes with knowledge ideas were classified as explanatory. About 19% of their notes with knowledge ideas were classified as elaborated facts. It has to be highlighted here that while we are interested in exploring age related (and hence cognitive maturity related) differences in students' knowledge building behavior, we are fully aware that there could be other possible reasons, such as the pedagogical contexts, that might contribute to the differences between the two grades of students. These issues are explored further in the discussion section.

Table 4. Distribution of numbers of notes with knowledge ideas at different levels of explanation for the two grades of students

Grade		Levels of Explanation				
		Factual		Explanatory		
		Fact-Unelab.	Fact-Elab.	Expl.-Unelab.	Expl.-Elab.	Total
Sixth	Number	550	174	148	46	918
	%	59.9	19.0	16.1	5.0	100
Tenth	Number	512	182	188	64	946
	%	54.1	19.2	19.9	6.8	100

Questioning and Levels of Explanation with a Thread as the Unit of Analysis

Taking a thread as the unit of analysis, we calculated the average level of explanations and average level of questions of each thread by averaging the levels of explanation of knowledge ideas and the levels of questions within the thread respectively. The total number of questions asked in each thread was employed as a quantitative measure. As can be seen in the correlation matrices presented in Table 5, a significant positive correlation was found between the average level of explanations and average level of questions of a thread for the tenth-grade students ($r=.38$, $p<.001$), suggesting that a thread with better questions generated was more likely to contain notes with better knowledge ideas expressed. However, the correlation was not significant for the sixth-grade students. For both grades, no correlation was found between the average level of explanations of a thread and the number of questions found in a thread. Moreover, no correlation was found between the level of questions and the number of questions asked in a thread for both grades, suggesting that there was no relationship between the quality and quantity of questions in a thread.

Table 5. Correlation matrices of variables of questioning and levels of explanation among all threads

Sixth-grade (n=114 threads)	(1)	(2)	(3)
(1) Average level of explanations	1.00	.15	-.00
(2) Average level of questions		1.00	-.04
(3) Total number of questions			1.00

Tenth-grade (n=184 threads)	(1)	(2)	(3)
(1) Average level of explanations	1.00	.38**	.00
(2) Average level of questions		1.00	-.15
(3) Total number of questions			1.00

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

Questioning and Levels of Explanation with a Student as the Unit of Analysis

Taking a student as the unit of analysis, we calculated the average level of explanations and average level of questions of each student by averaging the levels of explanation of his/her knowledge ideas and the levels of his/her questions respectively. The total number of questions asked by each student was employed as a quantitative measure. As seen in the correlation matrices in Table 6, the average level of explanations of a sixth-grade student was related to the quality (r=.54, p<.001) but not the quantity of questions. In other words, for the sixth-grade students, those who expressed better knowledge ideas were likely to be those who asked better questions. For the tenth-grade students, neither the quality nor the quantity of questions was related to the average level of explanation. Moreover, there was no correlation between the quality and the quantity of questions asked by a student for neither of the grades.

Table 6. Correlation matrices of variables of questioning and levels of explanation with a student as the unit of analysis

Sixth-grade (n=86 students)	(1)	(2)	(3)
(1) Average level of explanations	1.00	.54**	.07
(2) Average level of questions		1.00	-.03
(3) Total number of questions			1.00

Tenth-grade (n=80 students)	(1)	(2)	(3)
(1) Average level of explanations	1.00	.09	-.11
(2) Average level of questions		1.00	-.16
(3) Total number of questions			1.00

*: p<.01; **: p<.001

Questioning and Levels of Explanation with a Group as the Unit of Analysis

Taking a group as the unit of analysis, we calculated the average level of explanations and average level of questions of each inquiry group by averaging the levels of explanations of knowledge ideas and the levels of questions generated by the group respectively. The correlation matrices are as presented in Table 7. It can be seen that the average level of explanations was positively correlated to the average level of questions of a group for both the sixth-grade and tenth-grade students. The high correlation coefficients (.70 and .75) suggested that the relationships were strong. On the other hand, the average level of explanations and the average level of questions were not significantly related to the number of questions asked by a group for neither of the grades.

Table 7. Correlation matrices of variables of questioning and levels of explanation with a group as the unit of analysis

Sixth-grade (n=15 groups)	(1)	(2)	(3)
(1) Average level of explanations	1.00	.70*	-.01
(2) Average level of questions		1.00	-.26
(3) Total number of questions			1.00

Tenth-grade (n=12 groups)	(1)	(2)	(3)
(1) Average level of explanations	1.00	.75*	-.22
(2) Average level of questions		1.00	-.56
(3) Total number of questions			1.00

*: p<.01; **: p<.001

Case Studies of the Discourse of the Two Grades of Students

To deepen our understandings of the above quantitative results and to explore the different patterns of relationships in the two grades of students, case studies are presented in this section. A case is a bounded system that provides a real example that helps readers to understand some more general principles and relationships (Cohen, Manion, & Morrison, 2000). We choose a "group" as the case as it is the bounded system that contains a few students on the one hand and a few threads on the other. Hence it can help to illustrate the findings of the individual-level and thread-level relationships between questioning and the quality of knowledge constructed. Moreover, as a high correlation was found at the group level for both grades, we select a total of three groups in each of the grade to cover the range of high, middle, and low levels of performances in terms of both the levels of questions and the levels of explanations.

Three Cases of Sixth-Grade Groups

An overview of the three selected cases of sixth-grade groups that cover the range of performances in terms of both the levels of questions and explanations is as shown in Table 8.

Table 8. An overview of the three selected cases of sixth-grade groups

Group	Topic of Inquiry	Number of Students	Number of Threads	Mean Level of Explanations	Mean Level of Questions
A1	Energy Crisis	6	9	2.03	2.83
A2	Global Warming	6	6	1.88	2.13
A3	Global Warming	7	8	1.29	2.00

A High-performing Sixth-Grade Group

The first sixth-grade group (A1) was among the highest in both the mean level of explanations and mean level of questions. It had six students, studying the topic of Energy Crisis, and a total of nine threads were constructed. In the discussions, students mainly inquired on different forms of energy, including solar energy, wind energy and ground heat energy, and the reasons why there is energy crisis. Among the students in this group, Tommy (fake name) had the highest scores in both the mean level of explanations (2.67) and the mean level of questions (3.00). Jason (fake name), on the other hand, had the lowest scores in both the level of explanation (1.14) and the level of questions (2.00). The remaining four students were somewhere in between in terms of the mean levels of questions and mean levels of explanations.

Tommy asked a total of four questions, all of which were explanation-seeking ones, but they did not seem to be helpful in advancing the inquiry. For example, in the thread of "Ground heat energy", a student wrote that not all places are suitable for this form of energy and hence it is not that useful. Tommy responded by an explanatory question, "*But how come New Zealand can do it?*" Such a question could have driven the inquiry further into the exploration of how ground heat energy is used in New Zealand, but the exploration did not appear in this thread, as the question was not addressed by other students in this group.

In contrast, in the thread on "Solar energy", Tommy did not ask any questions but he contributed two notes with unelaborated and elaborated explanations respectively. In this thread, a student claimed that solar energy is not that useful because there may be rainy days. Another student opposed by arguing that the weather of Hong Kong, the city they live in, is usually hot. In response to this alternative idea, Tommy tried to differentiate whether temperature or the light condition is associated with the generation of solar energy, as indicated by the following excerpt,

"*Hot doesn't mean that there is enough sunlight, you need sunlight to heat up the solar panels. Just like today, although it is hot, there is no sunlight. While in Arctic, there are some extreme situations, like 10 days have sunlight, and 10 days NO sunlight.*"

From the beginning of the thread to the articulation of this note, no explanatory question was found. It suggests that even without explanation-seeking questions, students could still construct high-level explanations. In this example, the alternative ideas expressed earlier might be the trigger for the deepening of explanations rather than questions.

A Mid-performing Sixth-Grade Group

The second sixth-grade group (A2) was among the middle in both the mean level of explanations and mean level of questions expressed. Six threads were constructed in this group of six students studying Global Warming. Among the students, Eliza (fake name) had the highest level of explanations (2.25) and the highest level of questions asked (2.67). On the contrary, Judy (fake name) had the lowest level of explanations expressed (1.00) and ranked the second lowest in the level of questions asked (1.67). Such a pattern was similar to that of the first group.

In the thread on “Solar energy car”, a student argued that solar energy car was not that useful as there might be rainy or cloudy days. Eliza responded by putting forward an explanatory idea that solar energy could be saved in a cell so that the car could still have power in rainy or cloudy days. Judy also contributed a note in this thread, which was a response to a fact-seeking question on which country is having cars that are driven by solar energy, and Judy's response was, “*I remember that it is Japan*”. It can be seen that the knowledge idea expressed by Eliza was more explanatory in nature as compared to Judy. Such a difference could also be been found in the nature of questions they asked. In the thread on “Natural gas”, a student proposed that there could be environmentally friendly fuels for cars; for example, there are taxis using Liquefied Petroleum Gas (LPG) as the fuel. Then

Judy asked a fact-seeking question, "*Except taxi, what kinds of vehicles are using LPG?*" In another thread, a student wrote that the government had proposed to use Hydrogen as an energy resource. Eliza asked an explanatory question of how Hydrogen could produce energy, but no further responses were received.

A Low-performing Sixth-Grade Group

The third sixth-grade group (A3) was among the lowest in both the mean level of explanations and mean level of questions. A total of eight threads were constructed in this group of seven students studying Global Warming. The knowledge constructed in this group was mainly factual in nature, and there was a large amount of copy-and-paste contents. For example, in the thread on "Information of global warming", which comprised a total of six notes, four notes were with copy-and-paste contents. Of the few explanatory questions found, they were either addressed with copy-and-paste contents or not addressed at all. For example, in the thread on "Ways to improve global warming", a student asked, "*How can technology solve global warming?*" Another student copied a paragraph from the internet as the answer to this question. No deepening of inquiry could be observed in this group.

Among the seven students, Teddy (fake name) had the highest level of explanations expressed (2.00) while his level of questions (1.67) ranked the fourth in this group. The numbers were much lower than those of the top students in the previous two groups. Three students had the lowest scores in the levels of explanations (1.00), but their levels of questions ranged from 1.50 to 2.17. Hence unlike the previous two groups, there was not a clear individual-level pattern in this low-performing group. It could also be said that no individual student in this group played a significant role to advance the knowledge by contributing good questions or high-level explanations.

Summary for the Case Studies of Sixth-Grade Groups

To summarize, the case studies suggest that generally speaking, for the sixth-grade students, threads containing high-level questions are often not the same as those containing higher levels of explanation even among threads constructed by the same group of students. This indicates that at the thread level, the knowledge advancements observed in the grade six classes are not propagated through higher-level questions generated by the students, but through other discourse mechanisms. On the other hand, it is observed that the higher-level explanations are often generated by students who also asked higher-level questions. It is however not clear whether this observed correlation is indicative of a cognitive link between the ability to ask explanatory questions and to construct explanations.

Three Cases of Tenth-Grade Groups

Presented in Table 9 is an overview of the three selected cases of tenth-grade groups that cover the range of performances in terms of both the levels of questions and explanations.

Table 9. An overview of the three selected cases of tenth-grade groups

Group	Topic of Inquiry	Number of Students	Number of Threads	Mean Level of Explanations	Mean Level of Questions
B1	Water Quality	8	11	2.35	2.66
B2	Ideal Vehicle	9	13	1.93	2.16
B3	Plastics	7	11	1.47	2.03

A High-performing Tenth-Grade Group

The first tenth-grade group (B1) had the highest scores in both the mean levels of explanations and mean levels of questions. Eight students participated in the discussions of this group, studying the topic of Water Quality. They contributed a total of eleven threads, inquiring into subtopics such as acid rain, reverse osmosis, and the usage of Chlorine gas, Ozone, and Ultra Violet to improve water quality. Charles (fake name) was the person with the highest mean level of explanations (2.65) in this group, but his mean level of questions (2.29) ranked the second lowest. On the other hand, Vincent (fake name) had the highest mean level of questions (2.90), but his mean level of explanations (1.50) ranked the second lowest. Hence unlike the sixth-grade students that those who asked good questions were likely to contribute high-level explanations, the tenth-grade students tended to have these two important acts shared among individual students. Nonetheless, the combination of good questions contributed by some students and high-level explanations contributed by others resulted in the construction of threads indicating deep inquiry. For example, in the thread on "Acid rain", Vincent, the contributor of good questions, asked, "*Acid rain causes the water to become acidic, can we use alkali to neutralize the water?*" A student addressed this explanatory question by writing that a lot of salt will be produced when alkali is used to neutralize the acidic water, which was further built onto by Charles with an explanatory idea,

"*Also, when we add alkali to the water that is polluted by the acid rain, although it can neutralize the acidic properties of the polluted water, the alkali will also affect the water quality or may kill the organism in the water. When acid and alkali are having neutralization, the reaction process will give out heat, it may also affect the habitat of the organism*."

Although Charles contributed a number of explanatory notes in the discussion, some question he asked were factual in nature. For example, in the thread of "Reclamation", he asked the question of what materials were used to reclaim the sea, which led to a factual response listing the materials that could be used for reclamation. On the contrary, Vincent, who asked a number of explanatory questions, tended to express factual knowledge ideas. For example, in the thread on "Acid rain", he wrote a note that summarized the factual information about acid rain from a quoted web-site.

A Mid-performing Tenth-Grade Group

The second tenth-grade group (B2) had medium scores among all the tenth-grade groups for both the mean levels of questions and mean levels of explanation for the notes they wrote on the topic of Ideal Vehicles. A total of nine students participated in the discussions, constructing 13 threads, inquiring into subtopics such as fuel, electric car, and materials for an ideal car. Among the students, Kenny (fake name) had the highest mean level of explanation (2.54), but his mean level of questions (1.83) was among the two lowest in this group. Kenny's explanatory notes were about the mechanisms involved in an electric car and a fuel cell. The questions he asked were mainly fact-seeking ones, such as whether the output of a fuel cell is strong or not. On the contrary, Henry (fake name) scored the lowest in the mean level of explanation (1.89) as his notes were mainly related to factual knowledge, but his mean level of the questions (2.38) ranked the fourth in this group. Such a pattern is similar to that of the high-performing group. This explains why for tenth-grade students, there is no statistically significant correlation between levels of questions and levels of explanation at the individual level.

Another similar pattern found in the two tenth-grade groups was that questions played an important role as a mechanism for knowledge advancement in threads. For example, in the thread on "Substance of fuels", students began their inquiry with a fact-seeking question of "*What is the chemical substance in fossil fuel?*", which received some factual responses, including LPG (Liquefied Petroleum Gas) and water. These factual responses led to an explanatory question on how water can be a kind of fuel, which resulted in further inquiry on the mechanism of fuel cells:

"*Fuel cells have been developed which convert hydrogen directly into electricity. This is attractive since the only byproduct is water. There are still significant problems since carbon dioxide is typically produced by use of electricity, which is mostly produced from fossil fuels*."

Although this thread did not start with an explanation-seeking question, explanatory questions were generated in the process of inquiry, which led to explanatory explorations as illustrated by the high level explanations on the mechanism of fuel cells contained in subsequent notes in the same thread.

A Low-performing Tenth-Grade Group

The third tenth-grade group (B3) had the lowest scores in both the mean levels of explanations and mean levels of questions. Seven students participated in the discussions, studying the topic of Plastics. Eleven threads were constructed to inquire into subtopics such as the classification of plastics, their common uses, and recycling. Sam (fake name) was the person with the highest mean level of explanations (1.80) in this group, and his mean level of questions (2.40) ranked the second highest. On the other hand, John (fake name) scored the lowest on the level of explanations (1.18) and was one of the two persons with the lowest score on the level of questions (1.67). Hence unlike the previous two tenth-grade groups, there appeared to be no sharing of the contributions of better questions and better knowledge ideas among individuals in this low-performing group.

The knowledge constructed in this group was mainly factual in nature. For example, in the thread on "Common uses of plastics", students began their inquiry with a fact-seeking question on "*What are the common uses of plastics?*" The other students responded by gathering the uses of plastics that they could think of. No deepening of inquiry was found in this thread. Occasionally, explanatory questions were asked, but they were either addressed with copy-and-paste contents or not addressed. For example, a student tried to divide plastics into two groups, those for domestic use and those for industrial use. Then Sam asked, "*Why plastics are not divided by their properties?*" But his explanatory question received no further responses. In another thread, one student mentioned some plastics are soft and some plastics are strong. Sam explained that "*Different kinds of plastics have different structures. Some of them are stronger.*" But there was no further build-on to deepen the inquiry. It seemed that the individual effort of Sam was not enough to help this group to advance knowledge. The majority of questions and knowledge ideas found were factual in nature.

Summary for the Case Studies of Tenth-Grade Groups

To summarize, the case studies of tenth-grade groups suggest that the students asking explanatory questions were not necessarily the ones who contributed high-level explanations. On the other hand, at the level of a thread, explanatory questions generated by students play an important role as a mechanism for knowledge advancement in the discourse; such a pattern is very different from what has been observed of the sixth-grade students' discourse.

DISCUSSION

This paper examines the relationship between questioning and the levels of explanations constructed in the context of CSCL. Although the reported correlation patterns seem to vary across different analytic units and between the two grades, one consistent finding is that the average level of explanations is not related to the number of questions asked no matter which unit of analysis is employed and which grade of students is studied. On the other hand, a significant correlation is found between the average level of explanations and the quality of questions asked for one unit of analysis for each of the two classes of students studied. In the following sections, we will discuss the relationship between the quality of questions and the levels of explanations for the analytic units of a student, a group, and a thread respectively.

Advancing Knowledge in a Thread Through Questioning

Analyses at the thread level are designed to explore whether better questions is dynamically related to the generation of higher levels of explanations in a threaded discussion. As knowledge building emphasizes students' questions as important resources to carry forward an inquiry and explanation-seeking questions are considered as more productive in terms of knowledge advancement compared to fact-seeking ones (Hakkarainen, 2003; Zhang et al., 2007), it might be expected that threads with high-level questions are likely to trigger high-level explanations. Nonetheless, a significant positive correlation is only found for the tenth-grade but not the sixth-grade students. The case studies also suggest that while the tenth-grade students seem to be able to advance their inquiry through questioning, the sixth-grade students seem less able to do so. It should be noted that the proportion of high-level questions asked is similar between the grades of students (see Table 3). However, as illustrated in the case studies, even some high-level questions are asked in the sixth-grade students' discourse, they might not lead to high-level explanations as they are not addressed by the other students.

A possible explanation is that the younger students, who were relatively new to knowledge building, might not be that familiar to conduct collaborative inquiry and advance knowledge together. More facilitation might be needed so that the younger students could advance their inquiry through questioning. For example, in the literature on knowledge building, Hakkarainen (2003) reported a case study of how a teacher could help students to further deepen their inquiry by clarifying some of their concepts. Teachers can also highlight the questions that have not been addressed for students to further their inquiries (see e.g., Zhang & Sun, 2011). Moreover, it is found that with more experience, student' engagement in knowledge building can be improved (e.g., Hakkarainen, 2003; Zhang et al., 2007). Further studies are needed to explore what kinds of teachers' facilitations and pedagogical designs are most appropriate to help students advance knowledge through questioning. A possible direction is to develop automatic or semi-automatic tools to help identify the quality of questions asked in a CSCL context (see e.g., Law, Yuen, Wong, & Leng, 2011), so that it will be easier for teachers to understand what kinds of questions the students are asking in their inquiries and to offer facilitation if necessary. Studies are also needed to examine whether the difference we observed is specific to these two groups of students, or whether there is really a developmental difference in conducting collaborative inquiry, and whether the difference is a result of the exposure to different educational experiences (see e.g., Lai & Law, 2006).

It should also be noted that the proportion of explanatory notes expressed by the sixth-grade students is only slightly lower than the tenth-grade students (see Table 4). In other words, although the sixth-grade students seem to be less capable of advancing knowledge through questioning, there could be other ways for them to advance knowledge. As indicated in the case studies, high-level explanations could be constructed in response to the alternative ideas expressed earlier for the younger students. For example, in response to the diverse ideas that whether solar energy is suitable in Hong Kong, a sixth-grade student tried to differentiate whether temperature or the light condition is associated with the generation of solar energy. In previous studies on knowledge building, there were also case examples showing that the act of putting forward alternative ideas might lead to the deepening of inquiry (see e.g., Chan, 2001;

Hakkarainen, 2003). One of the knowledge building principles is "idea diversity" (Scardamalia, 2002). In an earlier study that the knowledge building principles were employed to analyze the developmental trajectory of CSCL groups, it was found that "idea diversity" was one of the entry level principles (Law & Wong, 2003), suggesting that the exploration of diverse ideas might be a possible way for a deeper engagement in knowledge building. In future studies, more systematic analysis can be employed to explore how knowledge might advance through the presence of alternative ideas.

Students Asking Good Questions and Constructing High-level Explanations

At the individual level, it is found that for the sixth-grade students, those who ask better questions are also the ones who put forward higher levels of explanations. Such a relationship is not found among the tenth-grade students. It could also be said that for the young students, higher levels of engagement in knowledge advancement, i.e. formulating high-level questions or explanations, tend to be confined to a narrower group of students; while for the older students, there tends to be a more equal participation in terms of the advancement of knowledge, with some of them contributing good questions while the others high-level explanations. On the other hand, the observation of the cognitive behavior of the younger students suggest that asking good questions and constructing high-level explanations may not be connected as a form of collaborative discourse dynamics, but related through some form of personal attribute. In the literature, it is reported that the competence of asking better questions is related to a better level of conceptual understanding (Tisher, 1977; Harper et al., 2003). However, the "personal-attribute" viewpoint cannot be applied to the discourse of the tenth-grade students, as those who ask better questions are not the same as those who put forward high-level explanations. Within the scope of this study, it cannot be concluded that whether the difference is a result of developmental differences leading to changes in the relationship between these two competences among older students, or they are related to socio-dynamic factors such as some students being more adjusted to the role of contributing questions and others to contributing explanations. The latter could result in a "division of labor" such that good questions and high-level explanations are contributed by different persons, which in combination could lead to the advancement of knowledge through questioning at the thread level.

Further studies are needed to see whether the different patterns of relationship between questioning and knowledge idea construction can be observed in other samples of students, and whether such differences are age or developmentally related. In two previous studies that such an individual level relationship was examined, as reviewed earlier, a positive correlation was also found among primary grade (Hakkarainen et al., 2002) but not secondary grade students (Lee et at., 2006). It is important to explore whether contribution to knowledge advancement is dependent on some "personal-attribute(s)" for younger students, and whether there is a tendency for older students to evolve, as a community, into different roles: those who raise deep inquiry questions and those who construct good explanations in conducting collaborative inquiry. Good, Slavings, Hobson Harel, & Emerson (1987) argued that students' questioning behaviors are affected by their learning experiences throughout the years. In addition, variables such as students' academic achievement and conceptual understanding should also be included in future studies to examine their relationships with the capacities in asking good questions and constructing high-level explanations. Moreover, in the literature on CSCL, an equal participation usually refers to the equality based on quantitative measures such as the number of notes contributed (e.g., Lipponen, Rahikainen, Hakkarainen, & Palonen, 2002), the finding of the younger students suggests that qualitatively, there could also be an equal or unequal participation in CSCL, as good questions as well as high-level explanations tend to be contributed by some of the students but not the others. It further suggests that more facilitation or a suitable pedagogical design is needed to encourage a more equal participation in a qualitative sense for younger students.

High Correlation at the Group Level

While the two grades of students differ in the correlation patterns at both the thread and individual levels, a consistently high correlation between the level of questions and the quality of knowledge constructed is found at the group level for both grades. It is generally in line with the findings reported in King's (1994) and King and Rosenshine's (1993) studies. However, an experimental design was employed in their studies, in which the experimental groups received specific training on how to ask better questions, and the findings suggest that the experimental groups could ask better questions and construct better knowledge ideas compared to the control groups (King, 1994; King & Rosenshine, 1993). In the present study, none of the groups received specific training on questioning, and a strong relationship is observed between the quality of questions and quality of knowledge ideas at the group level. It suggests that for both grades, groups vary on their levels of performance in terms of the practices that are likely to contribute to productive knowledge building. The high-performing groups ask good questions and at the same time contribute high-level explanations, while the low-performing groups ask questions of low quality and at the same time contribute low-level knowledge ideas. It suggests that there might be a developmental trajectory in terms of knowledge building practices at the level of a group (see also Law, 2005; Law & Wong, 2003). The case studies also suggest that in the low-performing groups in both grades, there was no evidence of the deepening of inquiry. Further studies are needed to examine how to facilitate the groups with lower levels of performance. Since the results suggest that it is the quality rather than the quantity of questions that matters, studies that are related to helping students to formulate better questions (e.g., Choi, Land, & Turgeon, 2005; Cuccio-Schirripa & Steiner, 2000; Hartford & Good, 1982) might offer valuable insights to the facilitation of knowledge building pedagogy.

The findings also suggest that the correlation patterns found at the group level might need further interpretation. For example, it might be misleading if one infers that good questions are necessary and sufficient to trigger high-level explanations in the collaborative discourse if a high correlation is found at the group level, as our observations of the sixth-grade students demonstrate. The group level correlation for the tenth-grade students can be interpreted as a result of good questions providing an impetus for knowledge advancement on the basis of the thread level analysis. For the sixth-grade students, the group level correlation seems to be a result of the individual-level correlation—high-performing groups have individuals high on both scores of levels of explanations and levels of questions, while low-performing groups have individuals low on both scores. To further investigate how the three levels of correlation patterns are related to one another, a multi-level analysis (Goldstein, 2003) can be conducted in the future based on the nested structure of individual—thread—group.

Limitations of this Study

One limitation of this study is that there could be other reasons contributing to the observed differences between the two grades of students other than the factor of age. For example, the students were studying in different schools, taught by different teachers, and had their own backgrounds; the pedagogical contexts and implementation procedures were also different for the two grades (see the section on Method). Although grade level differences are reported, there are also a number of similar findings between the two grades. First of all, an equally high correlation is found between the quality of questions and the quality of knowledge ideas at the group level. Secondly, although more questions are asked by the tenth-grade students, the proportion of explanation-seeking questions found is similar between the two grades (see Table 3). Thirdly, the distributions across different levels of explanations are also similar between the two grades (see Table 4). The major differences between the two grades are the correlation patterns observed at the individual level and the thread level. More studies are needed to see whether our findings can be generalized to other samples of students of different grade levels.

Another limitation of this study is that the participants, both students and teachers, were relatively new to knowledge building as a pedagogical approach, and the length of inquiry of both grades was about six weeks, which was shorter than the period reported in previous studies, in which the inquiry might take several months (e.g., Hakkarainen, 2003; Lee et al., 2006; Zhang et al., 2007). Hence the students, especially the younger ones, might not have developed the capacity to advance their knowledge through questioning. It is expected that with more experience in knowledge building, students could become more capable of advancing knowledge together, as what is reported in the literature (e.g., Hakkarainen, 2003; Zhang et al., 2007).

Thirdly, we only analyze one dimension of questions in this study, namely, the epistemological nature of questions. We chose this dimension because it is widely employed in the literature on knowledge building. There are other dimensions tapped by other analytic frameworks of questions (e.g., Dillon, 1984; Graesser & Person, 1994). For example, Graesser and Person (1994) differentiated categories such as questions of comparison, causal antecedent, causal consequence, interpretation, expectation, and goal orientation. Different types of questions might have different roles in the process of knowledge advancement. Future studies can explore whether other dimensions of questions are related to the quality of knowledge constructed. As the case studies suggest that some good questions asked by the younger students are not addressed by the others, further studies with a more fine-grained categorization of questions might help to understand whether there are some sorts of questions that are less likely to be addressed among younger students in conducting collaborative inquiry.

Finally, both quantitative and qualitative methodological approaches were adopted in this study. The correlation analyses were employed as an exploratory tool to reveal possible patterns of relationships. Then the qualitative analyses through case studies were employed to have an in-depth understanding of the relationships between questioning and knowledge construction. In the quantitative analyses, however, as argued by Stevens (2009), there might be a violation of independent observation in the context of CSCL that students can interact and hence are not independent from one another. In this paper, we employed a more stringent alpha level (.01) to correct for sources of possible errors as a result of the assumption of independence of observation being violated (see Stevens, 2009: p.219). Multi-level methods (e.g., Goldstein, 2003) might provide another possible way for analyzing the current data, which involve a nested structure of individuals, threads, and groups.

CONCLUSION

With the differentiation of three different units of analysis (an individual, a group, and a thread), this study examines the relationship between questioning and the quality of knowledge ideas of two grades of students in the context of CSCL. Some different and some similar correlation patterns are observed across different analytic units and between the two grades. At the thread level, a significant correlation is found for the tenth- but not the sixth-grade students, suggesting that the tenth-graders are more capable to advance knowledge through questioning, while for the sixth-graders, more facilitation seems to be needed. The findings also suggest that further research is needed to explore other factors that may affect the level of explanations of a thread. At the individual level, for the sixth-graders, those asking good questions are likely to express high-level explanations, suggesting that individual competence might play an important role in the making of knowledge advancement, and there seems to be an uneven participation in a qualitative sense among these younger students. For the tenth-graders, there seems to be a "division of labor" that good questions are likely to be generated by some students while high-level explanations are likely to be generated by others. At the group level, a high and positive correlation is found for both grades, suggesting that groups with better questions generated are very likely to be those with high-level explanations expressed. The findings also suggest that correlation patterns found at the group level have to be interpreted carefully as they might be different from those at the individual and thread levels.

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