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Promoting Knowledge-Creation Discourse in an Asian Primary Five Classroom: Results from an Inquiry into Life Cycles

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Abstract

The phrase 'knowledge creation' refers to the practices by which a community advances its collective knowledge. Experience with a model of knowledge creation could help children to learn about the nature of science. This research examined how much progress a teacher and 16 Primary Five (Grade 4) students in an International Baccalaureate Primary Years Programme (IB PYP) could make towards the discourse needed for Bereiter and Scardamalia's model of knowledge creation. The study consisted of two phases: a five-month period focusing on the development of the classroom ethos and skills needed for this model (Phase 1), followed by a two-month inquiry into life cycles (Phase 2). In Phase 1, we examined the classroom practices that are thought to support knowledge creation, and the early experiences of students with a Web-based inquiry environment, Knowledge Forum®. In Phase 2, we conducted a summative evaluation of student work in Knowledge Forum in light of the model. Data sources included classroom video recordings, artefacts of the in-class work, the Knowledge Forum database, a science content test, questionnaires, and interviews. The findings indicate that the students made substantial progress towards knowledge-creation discourse, particularly regarding the social structure of this kind of discourse and, to a lesser extent, its idea-centred nature. They also made acceptable advances in knowledge and appeared to enjoy this way of learning. The study provides one of the first accounts in the literature of how a teacher new to the knowledge-creation model enacted it in an Asian primary classroom.

Introduction

In the last decade, there has been considerable interest in the use of argumentation in science education (Erduran, Simon, & Osborne, 2004; Kuhn Berland & Reiser, 2008). Although oppositional arguments in which one party attempts to persuade another are perhaps more familiar, dialogic arguments are educationally more interesting. According to dialogue theory, an argument is ‘a move made in a dialogue in which two parties attempt to reason together’ (Andriessen, 2006, p. 445). Dialogic argumentation involves considering new information and experiences in light of one’s currently held beliefs and considering a problem or issue from multiple perspectives.

The science education literature gives two main reasons for emphasising (dialogic) argumentation. First, argumentation can help students learn science content by providing them with an opportunity to ‘construct, and reconstruct, [their] own personal knowledge through a process of dialogic argument’ (Driver, Newton, & Osborne, 2000, p. 298). Second, argumentation is a key process by which scientific knowledge is advanced. Argumentation in science is usually neither oppositional nor aggressive but rather ‘a form of collaborative discussion in which both parties work together to resolve a issue, and in which both scientists expect to find an agreement by the end of the argument’ (Andriessen, 2006, p. 443). Engagement in argumentation may help students see that the claims of science are often contested, and that knowledge that was once considered reliable can again become controversial (T. S. Kuhn, 1970). As a result, many science educators promote argumentation on science controversies (Bell, 2004) and socioscientific issues (e.g. Walker & Zeidler, 2007).

If students are to engage in argumentation, then it is crucial to encourage classroom interactions in which students are willing to contribute their ideas, listen to the ideas of others, and attempt to work together to make sense of various ideas. The extensive literature on classroom discourse shows that such a practice is challenging in Western contexts. For example, the IRE structure (the teacher initiates, the student responds, and the teacher evaluates), first identified by Mehan (1979), constrains student-to-student talk, and Gallas (1995) observed that primary school boys frequently shouted out responses in class discussions before their turn, limiting opportunities to enter the discussion. Substantial effort has been invested in Western classrooms to address such problems (e.g., van Zee & Minstrell, 1997). In Asian classrooms, which are influenced by Confucian values, and in which students avoid challenging the authority of the teacher, figuring things out for themselves, and 'losing face' by sharing ideas that they know require improvement (Chin, 2006; Lee, 1996), engaging students in classroom discourse is even more difficult. In Hong Kong, even primary (elementary) schools are very competitive, because students need to compete for places in secondary schools with strong academic programmes. Much more research is needed to examine how to cultivate learning environments that support dialogic argumentation in Asian contexts.

This study addressed these problems in the context of a teacher's first attempt, over a period of seven months, to implement an educational approach that emphasises dialogic argumentation in a Primary Five (P5) class, taught by the second author at an international school in Hong Kong. This approach has previously been known as 'intentional learning' and 'knowledge building' (Bereiter & Scardamalia, 1989, 1993; Scardamalia & Bereiter, 2006) but is currently called 'knowledge creation' for its close parallels to the literature on knowledge-creation and innovation (e.g., Engeström, 2001; Nonaka & Takeuchi, 1995). Consistent with the literature on this approach, we prefer to use the term 'discourse' rather than 'argumentation' to refer to the talk, writing, and other actions that have meaning within a community; it includes a broader set of practices than the language-intensive ones usually associated with argumentation. For example, student poster presentations would be part of a class's discourse. In this study, part of the discourse occurred in a Web-based inquiry environment, Knowledge Forum® (Scardamalia, 2003). The eventual goal of our research programme is to develop the knowledge-creating model as a method for Asian students to learn about the nature of science. This study marks an initial step in this direction; however, it does not examine student understanding of the nature of science. Rather, it focuses on the practices used to support knowledge creation and investigates the nature of student discourse in Knowledge Forum.

The study consisted of two phases. Phase 1 was a five-month exploration to determine how to create the classroom conditions for knowledge creation, focusing on three practices: a knowledge-creation contract that clarified the relationship between knowledge-creation activities and the school curriculum, a visual representation of knowledge-creation discourse consisting of index cards and string affixed to a wall (a 'knowledge wall'), and a format for class discussions (Quality Circle Time; QCT). During this phase, students also learned to use Knowledge Forum. Phase 2 was a two-month science inquiry unit on life cycles, in which these practices were integrated into a coherent whole. The goal of this phase was to conduct a summative evaluation of how far the class was able to advance towards discourse consistent with the knowledge-creation model. The analysis focused on the extent to which work on Knowledge Forum was oriented towards building explanations (theories) and the scientific quality of those explanations. To check the suitability of the approach for addressing this science topic we also checked students' knowledge (pre- and post-test) and their thoughts about using Knowledge Forum. The research questions were:

1. To what extent do the contract, knowledge wall, and QCT facilitate the classroom discourse necessary for knowledge creation?
2. To what extent can the online discourse be considered knowledge creation?
3. What are the beliefs and feelings of students about the quality of their work on Knowledge Forum?

Theoretical Background

Knowledge creation

'Knowledge creation' refers to the practices by which a community advances its collective knowledge, and is closely related to innovation (Paavola, Lipponen, & Hakkarainen, 2004). It is not simply the creation of an idea during a flash of insight, but requires discourse to identify gaps in the community's collective knowledge and evaluate whether a new idea constitutes an advance. New ideas need to be questioned theoretically and their usefulness tested. They also need to be improved. The social practices by which knowledge is created in science have been the subject of extensive research (e.g., Dunbar, 1995; T. S. Kuhn, 1970; Latour, 1987; Paavola et al., 2004) and do not need to be elaborated here. However, drawing from Popper's (1972) notion of 'objective knowledge', it is worth underscoring that in knowledge-creation discourse, ideas are not just held in a person's mind but are *out-in-the-world* objects. As Bereiter and Scardamalia (2003) point out, we can ask questions about them such as 'What is this idea good for?', 'What problem can this idea not explain? ', and 'How can this idea be improved?'.

The pedagogical approach that we call knowledge creation is based on two assumptions. First, although young children know much less than scientists, it is assumed that they can begin to use the approaches to learning that scientists use to create new knowledge, including identifying major gaps in the community's knowledge, setting learning goals and identifying ways to address them, and working together to improve the community's ideas over time (Bereiter & Scardamalia, 1993). In other words, students' work is considered part of the life of a community—a group of people they identify with, share practices with, care for, and whose knowledge they are working to improve. Within these communities, students are not expected to 'discover' reliable science knowledge on their own; rather, they start from their current knowledge, study available information sources, conduct experiments, and gradually elaborate more powerful and coherent knowledge. The teacher plays an essential role by creating a social and epistemic environment in which this work can take place, for example by helping students to work more effectively in groups and develop promising lines of inquiry. However, the teacher rarely sets tasks for the students to complete, and the children have far more responsibility for their own learning than is typical in school. Scardamalia (2002) refers to the kind of agency needed for the collaborative creation of knowledge as 'epistemic agency'.

The second assumption is that engagement in knowledge creation can lead to a more accurate understanding of the nature of science—especially of science as a social practice and of scientific knowledge as open to refutation and improvement. This assumption is similar to the second reason for promoting dialogic argumentation mentioned in the introduction, that argumentation is a key process by which scientific knowledge is advanced (Driver et al., 2000). In this respect, the purpose of discourse is not to 'get the correct answer' (known at the outside by the teacher) but to make progress towards better knowledge within the community. 'Better' can refer to many types of improvement including better understanding of the evidence base and arguments for knowledge claims (D. Kuhn, 2005), better understanding of the limits of the appropriate use of knowledge, and more powerful ideas that fit into a coherent explanatory framework. Here, too, the role of the teacher is crucial. Although the teacher need not know the answers to all of the questions that the students are pursuing, he or she needs to be able to create an environment that encourages investigation, argumentation, the evaluation of evidence, and reflection on what is being learned.

The pedagogical perspective is only an approximation to scientific knowledge-creation communities. Students know much less than scientists and need more mentoring, and a knowledge-creation culture does not generally pre-exist in classrooms (White & Fredericksen, 1998); scientific communities evolve more than classes of students (Barab, Kling, & Gray, 2004); and scientists tend to be concerned with the day-to-day details of their research rather than think about a context-independent epistemology of science (Wong & Hodson, 2009). Nevertheless, we believe that the knowledge-creation framework can provide a powerful way for students to improve their knowledge of science including knowledge of the reliable features of its epistemology.

Computer support for knowledge creation

In most implementations, Knowledge Forum, a Web-based inquiry environment, is used to support knowledge-creation discourse through a number of features, four of which we briefly describe (see Figure 1 and Scardamalia, 2003). (1) It provides a place where students can share their ideas. It has been observed by teachers as well as researchers that many more students can participate in asynchronous online discussions than in face-to-face discussions, and that their contributions are more reflective (e.g. Cummings, 2003; Hoadley & Linn, 2000). (2) It provides a place where students can collaboratively work on ideas. To facilitate such work, Knowledge Forum includes a set of modifiable scaffolds—labels such as ‘My Theory’, ‘I need to Understand’, and ‘New Information’. For example, use of the My Theory scaffold by a student would indicate that further work (testing, elaboration, etc.) is needed for the presented idea; this would not be implied, however, should the New Information scaffold be used. Knowledge Forum also includes shared workspaces called ‘views’ and a private workspace. For example, the icon of a note that was originally contributed to a view that explores students’ initial ideas could be copied to a view on ideas that need further inquiry. (3) It provides a reliable record of how the community’s ideas are developing over time. This is useful during relatively short arguments, but becomes essential when students need to reflect on learning that develops over a time span of months (e.g., their increased ability to pose questions or make use of evidence). (4) It provides tools for linking ideas, summarising lines of inquiry, and making conceptual progress visible. It is important that the use of Knowledge Forum extend beyond its use for online discussions to the use of the last two features in this list (van Aalst, 2009).

[Insert Figure 1 about here]

Prior studies in primary school science in Western countries

A considerable amount of research has been conducted on the knowledge-creation efforts of Canadian and Finnish students in primary science topics, including electricity, heat, forces, the human body, the solar system, and optics. Throughout most of the 1990s, research focused on the cognitive, metacognitive, and epistemic features of student computer notes, and the associated gains in literacy. For example, Oshima, Scardamalia, and Bereiter (1996) divided students in a combined Grade 5/6 class studying electricity into high and low conceptual progress groups and found that students in the former group were more focused on problem-centred knowledge, more frequently used interactive information flow between problem-centred and factual knowledge, and used graphics more frequently to represent problem-based knowledge than students in the latter group.

Hakkarainen (2003) used databases on science topics from three successive classes of two teachers to examine the level of explanation (from isolated facts to well-elaborated explanations), epistemic nature of questions (*how* and *why* questions that required an explanation, versus *who*, *where*, *when*, and *how many* questions that required facts), and extent to which students had a personalised epistemology (i.e., whether they considered ideas as their own or shared objects of inquiry). He found that the students of one teacher consistently produced higher-level explanations, which result was correlated positively with a high proportion of explanation-seeking questions and negatively with evidence of a personalised epistemology. Hakkarainen related these results to the classroom culture, noting that the teacher whose classes produced higher-level explanations had set projects that required students to articulate explanations. Hakkarainen and colleagues then worked to cultivate a high proportion of explanation-seeking questions. In one case study of Finnish Grade 5 students, it reached 83% (Lipponen, 2000).

Based on this research and experience in Western classrooms, Scardamalia (2002) developed a system of 12 principles that describe the sociocognitive and sociotechnological dynamics of knowledge creation. These principles are currently used throughout the international community working on the knowledge-creation model to help teachers to think about how to create the conditions needed for knowledge creation (see www.ikit.org). Zhang, Scardamalia, Lamon, Messina, and Reeve (2007) selected four that they considered the most relevant to their study (real ideas/authentic problems, idea improvement, community knowledge, and constructive use of authoritative sources) to analyse an online discourse on optics of a Grade 4 class over four months. These authors took as the unit of analysis the sequence of all computer notes on the same line of inquiry, and rated the notes within such ‘inquiry threads’ for depth of explanation and depth of inquiry. The results indicated that the students generated theories and explanation-seeking questions, designed their own experiments to test their theories, located and introduced authoritative sources, revised their ideas, and responded to emerging problems.

Despite substantial progress, there are several significant gaps in the literature. (1) Most studies have focused on databases and neglected classroom events. We believe that substantial research is needed to elaborate how the social conditions required for knowledge creation can be created in classrooms. It is clear that the question is not simply to add new activities or technology to classrooms—a fundamental cultural transformation is needed to bring into focus student agency, the advancement of the state of knowledge of the community, and an epistemic view of ideas as improvable objects. (2) Most research has been conducted in contexts in which the teacher, and sometimes the students, had several years of experience in using the knowledge-creation approach. There is little research, however, into how much progress towards knowledge creation is possible within a single school year by a teacher and students new to this approach. (3) Few studies have been conducted in Asian contexts. (4) Little research exists that examines knowledge creation as a possibility for addressing science education goals.

Participants and Research Context

The participants were 16 students in Primary 5 (Grade 4; ten girls and six boys aged 9 to 11), who were studying at a bilingual international school in Hong Kong. Their nationalities were Hong Kong Chinese, Singaporean, Malaysian, and mainland Chinese. The educational level of their parents was high, and many students had experience living in Europe or North America. They were taught in English by the second author, and were studying in the International Baccalaureate Primary Years Programme (IB PYP), which emphasises inquiry. However, students had worked individually rather than contributing to a collective inquiry by the whole class, and inquiry tended to be more structured than it is in the knowledge-creation approach, following, for example, the 5E model (engagement, exploration, explanation, elaboration, and evaluation; see Bybee et al., 2006). The students had no prior experience with Knowledge Forum. Although the students and context were more 'Westernised' than is the case in most public schools in Hong Kong, the students had spent most of their lives in Asian countries, and could be expected to have Confucian values and be competitive and achievement oriented. The IB PYP curriculum, with its emphasis on inquiry-based learning, also provided a more promising context for exploring the knowledge-creation approach than would a context with more emphasis on direct (didactic) teaching.

The teacher had five years of teaching experience; she was completing a Masters degree in science education at the time of the study. Prior to the study, she had attended an international conference on the knowledge-creation model and attended several local workshops. Thus, she had experience in guiding student inquiries, and had had opportunities to learn the theoretical background of the knowledge-creation model and how to use Knowledge Forum. She had not previously used an online discussion environment in her teaching.

Curriculum

The International Baccalaureate Primary Years Programme (IB PYP) curriculum emphasises cross-disciplinary skills and dispositions including inquiry, risk-taking, communication, and self-management. During Phase 1, these skills and dispositions were developed through short inquiries into a variety of subject areas. Students addressed driving questions using library and Internet resources and audiovisual materials available at the school, and participated in a variety of activities to make sense of the information they encountered. Phase 2 involved an extended science inquiry unit on life cycles that emphasised change and causation. In addition to drawing on the abovementioned resources, students visited exhibits on human reproduction and the frog life cycle at a science museum. Lines of inquiry focused on such topics as changes in the human body during different phases in the human life cycle and how they affect people.

Data Collection and Analysis

Figure 2 shows the data collection and analysis methods for the two phases. In Phase 1, the focus was primarily on classroom activities, and data collection from Knowledge Forum was limited to the examination of participation levels and the social structure of the discourse, and exploratory content analysis. In Phase 2, the emphasis shifted from the classroom to Knowledge Forum. We employed analytical techniques that are widely used in the study of Knowledge Forum databases to benchmark the discourse against that examined in other studies.

[Figure 2 about here]

Classroom observations

To our knowledge, few studies have documented how teachers get knowledge creation started in their classrooms. Therefore, to address the first research question, we aimed to describe the three practices (their nature and rationale and how they were used) and to reflect on the extent to which they functioned to support knowledge creation. Data collected for this purpose included teaching materials, student work, video recordings of some lessons, photographs, and reflections on teaching. The account we created reifies the teacher's understanding from multiple sources including the literature on the knowledge-creation approach, her interpretation of institutional values, and her teaching experiences, while the data collected served as resources when talking through her interpretations with others. To improve the external validity of the account (Yin, 2003), we presented it to other teachers and researchers.

Contributions to Knowledge Forum

Individual contributions. These include the number of computer notes created and read, the percentage of notes that are linked to each other, and the percentage of notes with keywords, scaffolds, or references. Although such measures are difficult to interpret without also examining the content of the computer notes, they do give an indication of possible problems. For example, they can signal that a significant number of students have not yet contributed a note or that there are few linkages between notes.

Social networks. A group of students can be considered a social network and the extent of interaction among them analysed. For example, consider an interaction of the following type: Student A has read five notes by Student B. How many of the possible links of this type are realised in the network? Analysis of this kind may reveal that there are students whose contributions have been read by nearly all (or none) of the students, or that ideas have been 'brokered' by only a few students. Social network analysis has been used widely in research into computer-supported collaborative learning (CSCL) and provides an overview of the social structure of a group engaged in discourse (de Laat, Lally, & Lipponen, 2007; Haythornthwaite, 2002).

Inquiry threads. In the literature on online discourse, a sequence of connected computer notes is called a 'discussion thread' (Hewitt, 2003). Examples of such threads are conferences in online conference systems, and chains of notes in which later notes are responses to earlier ones using a respond function in the software ('Build-on' in Knowledge Forum). However, such threads do not provide a good unit of analysis for at least two reasons. Sometimes, later notes build on earlier notes without making a direct link to them, and discussions often drift away from the main topic. Zhang and colleagues (2007) introduced the 'inquiry thread' to circumvent this problem. An inquiry thread is a time-ordered sequence of contributions (notes or smaller units) that pursue a single line of inquiry and need not be physically linked. An analysis of inquiry threads is a convenient way to show that a line of inquiry has been sustained for several weeks or that new ones have emerged from time to time. Each inquiry thread includes the following information: the number of notes in the thread, the number of students who were involved in writing them, and the number of students who (on average) read the notes in the thread. The second author read all of the notes from Phase 2 and grouped them into topics—the inquiry threads—based on the content of the notes, especially the consistent use of keywords. For example, notes that used a specific keyword were considered candidates for the same thread. A research assistant then repeated the whole process; agreement between the independent coders for the placement of notes in threads was 0.95.

Questions. To understand the meaning that questions have within a discourse, it is important to examine them in the context of the discourse, such as in light of previous contributions or the intentions of participants (Lemke, 1990; Stahl, 2002; Wells, 2001). Nevertheless, the application of rating scales to individual questions that have been taken out of context remains useful for examining the extent to which questions of different epistemic or conceptual levels are being asked, and continues to be practised widely in research into knowledge creation and CSCL in general (Chan, 2001; Hakkarainen, Lipponen, & Järvelä, 2002; Lipponen, 2000; Zhang et al., 2007). For example, Hakkarainen et al. (2002) found that explanation-seeking questions were associated with better knowledge advances than fact-seeking questions; knowing that few explanation-seeking questions are being asked provides an important indicator of the quality of discourse. The present study used a qualitative rating scale with three levels (van Aalst, 1999): Fact Oriented (Level 1), General (Level 2), and Explanation Seeking (Level 3). For example, ‘Do plants have hormones?’ was rated Level 1, whereas ‘How come they will grow an inch in a day?’ requires explanation and was coded Level 3. An example of a Level 2 question is ‘When the sperm and the egg meet, how long does it stay?’, which does not ask for a fact that students can easily look up and does not require an explanation. The 25 questions in the inquiry threads were rated independently by the authors; the inter-rater reliability was 0.82 (Cohen’s kappa).

Ideas: These were rated using a scale from Galili and Hazan (2000), which includes four qualitative levels: pre-scientific, hybrid, basically scientific, and scientific. Following Zhang et al. (2007) we refer to this scale as the ‘scientificness’ of ideas. Pre-scientific ideas contain misconceptions or lack information that could be used to develop more advanced ideas, whereas hybrid ones may reveal misconceptions but include information that could be used to develop more advanced ideas (e.g. ‘Trees have sap: a kind of like blood but for plants. I think that the seed will start of with a drop of sap inside. The sap will gather air and bits of nutrients together and make more sap’.) Basically scientific ideas are those that would generally be accepted by the teacher, whereas scientific ones integrate more information, for example, by elaborating or giving an example. One explanation that was rated scientific described what plants need to grow. It then listed the stages of the life cycle of plants, and related the process to an everyday experience: ‘The stages of a plant’s life cycle are seed, germination, plumule, radicle, flowering, pollination, ovary grows and fruiting. Plants that have fruit like: apple tree, orange tree, grape tree . . . reproduce by seeds from their fruits. The memosa in my house is still growing, I found out that it closes at night’. In total, 180 idea units were identified and rated by the second author, 40 (22.2%) of which were rated independently by the first author. The inter-rater reliability was 0.78 (Cohen’s kappa).

Pre-post science test

Although it was not the main focus of the study, an exploration of knowledge creation needs to include a test of students' knowledge of the science topic. Therefore, a test designed by the teacher, but based on the IB PYP intended learning outcomes, was given at the beginning and end of the life cycles inquiry unit in Phase 2. It asked students to order the seven major stages of the human life cycle (fetus, infancy, childhood, adolescence, adulthood, old age, and death), and then to answer a series of free-response questions, explaining in detail physical and psychological changes during puberty and adulthood and relating them to personal experience. Examples of these questions are: 'How does one cell, the size of a grain of sand, turn into an infant'? 'What happens during the toddler stage of childhood and how long does it last'? 'Why do we say that adulthood starts the cycle all over again'? The questions also provided opportunities to check student understanding of new vocabulary. Students were given as much time as they needed to complete the test on both occasions. (The test is available from the first author.)

Questionnaires and interviews

To probe the beliefs of students about knowledge creation and their experience with Knowledge Forum, a brief questionnaire was administered and group interviews were conducted at the end of the life cycles inquiry unit. Students were asked to share their beliefs and feelings about the benefits and challenges of group collaboration and online discussions. The aim was to allow the students to express honestly their feelings about their first year of using Knowledge Forum. Students were asked to reflect on what they were able to do and how they participated in Knowledge Forum. The interviews were conducted in small groups and lasted approximately 25 minutes. Questions asked include: 'What did you enjoy and not enjoy about using Knowledge

Forum for learning?' 'What skills did you learn and which would you like to improve?' 'How would you describe learning with Knowledge Forum to someone who has never used it?'

Results from Phase 1

Contract

Parental and principal support for sustained investment in a new approach requires an explicit demonstration of how the approach can help to address curricular goals. At the participating school, addressing the International Baccalaureate Primary Years Programme (IB PYP) curriculum and its IB Learner Profile were essential. Therefore, the class developed a contract near the beginning of the school year to articulate how they could use knowledge-creation activities to demonstrate the Learner Profile outcomes.

To set the stage for writing the contract, the class spent several lessons to view a promotional video that shows the use of Knowledge Forum to study the science of the human body and to review the IB Learner Profile. The goal of these lessons was to create a respectful and caring environment, as students need to be able to participate in public discussions without fearing negative consequences (Lampert, Rittenhouse, & Crumbough, 1996). The teacher then presented a poster that showed the knowledge-creation approach in simple terms. She wanted students to connect knowledge creation, which was new to them, to their prior knowledge of the Learner Profile. Students shared personal examples to describe what each profile trait and attitude meant to them. They agreed that as PYP students, they should all aim to be inquirers, knowledgeable, thinkers, communicators, principled, open-minded, caring, risk-taking, balanced, and reflective. Next, students brainstormed how they could demonstrate these traits and attitudes through their knowledge-creation efforts, and entered their ideas on a chart. The chart was a contract that students signed to indicate their agreement to do their best to meet the expectations and goals articulated. The contract was posted in the classroom and computer lab, and was used as a reference throughout the year. The final contract is shown in Table 1.

[Insert Table 1 about here]

These procedures slowed down the class, but we think it was crucial for the class to have spent time on them. The teacher felt that it was important to develop a caring and psychologically safe environment that could support democratic, engaging, and challenging discussions in the classroom and on Knowledge Forum. We also doubted that students would have kept the IB Learner Profile in focus during their work on Knowledge Forum without the contract, which means that it would have been integrated less with classroom learning. The contract enabled students to express verbally their desire to be inquirers, risk takers, and open-minded learners, and represented an agreement among the whole class that students would be responsible for their own learning and help each other strive for collective knowledge creation. These early experiences were very helpful in setting the scene for the types of discussions that would occur throughout the school year. They were also a way to use the prior knowledge of students of the IB Learner Profile to help create a collaborative classroom culture for the upcoming knowledge-building work.

Knowledge wall

A ‘knowledge wall’ is a visual representation of student ideas posted on a wall, with index cards and string expressing ideas and connections between them. It has a long history in classroom work on knowledge creation, and was first used in the mid-1980s in Jefferson County School District (Kentucky, USA).

The purpose of the knowledge wall is to allow students to become accustomed to sharing ideas in a public space and idea-focused discourse. As noted by many authors, the dominant discourse structure in classrooms is the IRE structure, in which the teacher asks a question, the student responds to the teacher, and the teacher evaluates the response (Mehan, 1979). In Confucian-heritage contexts, the need to develop practices to create an environment in which it is safe for students to contribute ideas to a public space is even more important, because students are reluctant to question the teacher's authority and do not want to 'lose face' (Lee, 1996). The knowledge wall provided a visualisation and model of knowledge-creation discourse in Knowledge Forum, and gave students opportunities for additional practice of this kind of discourse in a face-to-face mode.

Idea cards (2 × 4 index cards) were introduced early in the school year as a way for students to continue knowledge-creation discourse in the classroom when the computers were not available. To make the process as similar as possible to Knowledge Forum, students were asked to use scaffolds and include their names and the date on their idea cards. They also read cards already on the wall, moved them around, wrote new cards to respond to ideas, and used string to show connections. The students created 46 cards based on a few class discussions on children's rights and related topics. They appeared to be engaged in the process, showing enthusiasm and helping another decide where best to place a card. The teacher encouraged students to contribute ideas. As most students put the date on their cards, the knowledge wall showed how the discussion continued and evolved over time with new ideas and questions.

The teacher informally analysed the idea cards to gain an impression of the strengths and weaknesses of the discourse. The majority of cards had a single idea, but there were also some comment cards, which typically expressed agreement with a previous statement. The majority of students also used scaffolds. Students posed relatively few questions (6 of the 41 cards), but the teacher concluded that these still made a significant contribution. Some cards sought explanations, whereas others wanted more factual examples to better understand the viewpoints or arguments. Many asked for explanations of unfamiliar vocabulary. When their peers gave definitions, the simple language and descriptions seemed beneficial to the students who asked for clarification. The questions they raised played an important function in opening up misunderstanding and resulted in new vocabulary.

We believe the knowledge wall made an important contribution to the development of the classroom ethos, particularly via risk taking by sharing ideas in a public space, being helpful to one another, discussion of potentially difficult topics (e.g., child abuse), ideas-focused discourse, and the high level of interest and engagement generated. One aspect adding to the risk taking was that spelling mistakes were in plain view and remained so for months. The students also appeared to have a sense of accomplishment from having created something together, which is an important aspect of knowledge creation.

Quality Circle Time

The teacher introduced Quality Circle Time (QCT) in September as another practice we used to encourage a safe learning environment that was conducive to open discourse. QCT is a democratic approach to whole-class talk that is widely used in Western elementary classrooms, with the following goals/features (Mosley, 2005):

- Improvement of morale and self-esteem
- A ‘listening system’ with set guidelines, including waiting for one’s turn to speak
- Rules to show respect and open-mindedness
- Incentives to motivate children to participate and follow rules

- Temporary withdrawal of QTC incentives (sanctions)

We combined these goals with what Cummings calls 'hunkering': working at the eye level of children to help them to express their own ideas. The eye-level tactic contrasts the common practice in Hong Kong schools, in which the teacher is at a higher level, signaling his or her position of authority. When QCT was first introduced in September, the teacher was always the leader of the discussions. Following Cummings' advice, she participated in the discussions and ensured that she was at the eye level of the students on the carpet or one of the chairs in the circle. She did her best to make students feel that she was part of the learning community and did not have all of the answers to their questions. At times she felt it necessary to assert her authority to refocus the class or encourage more student sharing.

Cummings' listening rules were applied to establish a listening system. Many students struggle with developing listening skills and speak out of turn, fidget, doodle, daydream, play, shout answers, and wave their hands around (Gallas, 1995). These are distractions to the speaker and surrounding listeners, which the teacher worked hard to reduce if not completely eliminate. By first establishing a firm listening system to create a supportive classroom culture, the teacher hoped to break old habits that were not conducive to knowledge creation. Cummings makes it clear that students must focus on listening to speakers, and that distractions such as raising one's hand are not acceptable. In his study, students who raised their hands were reminded to wait until the speaker was done and to just listen. In the present study, the teacher enforced the same rules. Over time, there was a general improvement in circle time and other face-to-face activities.

After students had become familiar with QCT, they took turns being the discussion leader for different discussions (beginning in February). When they arrived at school, they would go to the Classroom Role wall chart to see what their daily responsibilities were. These were rotated daily so that everyone had an equal chance to participate in various roles, which included discussion director, current news reporter, recycler, computer scientist, hygienist, whiteboard monitor, and read-aloud presenter. The discussion leaders would help begin and run the circle time under the teacher's supervision and often intervene to redirect the discussion. Two students shared this role so that they could support each other and develop leadership skills at the same time. Discussion leaders also reminded their classmates of the circle time rules when appropriate. At times, the discussion leaders themselves needed reminding by their peers.

We observed that students gradually became calmer in their relationships with one another and less disruptive. They learned that patience paid off and prevented consequences such as being asked to leave the group. In many ways, the experience that the students had with circle time was helpful in building a sense of community among them. The discussions, reflection, and collaborative games in which students participated provided opportunities for character and listening skills development. The teacher used QCT as a method to establish clear boundaries to create a physically and psychologically safe learning place in which children could learn and grow and share ideas and feelings, based on the expectation that when children feel safe and happy, they will be more willing to participate in knowledge-creation activities. The listening system was also helpful in preventing confident and vocal students from dominating the discussions, and allowed a more democratic exchange of ideas. This is an important requirement for knowledge creation represented by the principle of democratization of knowledge (Scardamalia, 2002).

Use of Knowledge Forum

In Phase 1, we were primarily interested in examining levels of participation and social networking and conducted only a cursory content analysis. Individual indices of participation compare favourably with other studies (Table 2). For example, on average students created 33 notes, whereas Cummings' students created an average of 20 notes in his first implementation of Knowledge Forum, which lasted five months. The social networks shown in Figure 3 are also encouraging, with network densities of 100% for reading and 34% for building on (directly responding to) a note. This means that each student was involved in at least five reading interactions with every other student in the class and at least three build-on interactions with one third of the class during this period. In general, students built onto fewer notes than they read, and there was little evidence of the existence of sub-groups (cliques) or students who acted as brokers of information, particularly for the reading network.

[Insert Table 2 and Figure 3 about here]

The teacher observed some changes in how students used Knowledge Forum during Phase 1. Initially, many seemed to treat their work on Knowledge Forum as similar to e-mail and conversation. They wanted to have a conversation with individual students or friends and indicated this by adding the target person's name in the note title (e.g. *Question for Nicholas*, Nov. 6). However, after a few sessions students began to see that working on Knowledge Forum was different from e-mail and became more aware that their audience was all of the students and the teacher. Another shift was in the focus of attention. The teacher often had to remind students to share their ideas and help each other advance their knowledge. They were asked to focus on the questions or problems raised in the discussions rather than writing conventions. Many students initially critiqued each other's spelling and grammar (e.g. '*That's nice*, but you spelled model wrong', Nov. 6). There were also many off-topic remarks or short comments in which students agreed with each other without building on ideas or offering explanations (e.g. '*Yah* I agree to this', Dec. 6). Over time, more notes elaborated ideas and information (e.g. 'It's not a castle Calvin, it's actually Beijing's Forbidden City', Feb. 20).

The students were asked to explain why and how they used Knowledge Forum. One student wrote, 'I use KF to chat with others and to spell check'. Other responses included using the software to share opinions, helping to build on classmate's knowledge, asking questions, and building on notes about different subjects. One student commented that having fun was an important element in the process: 'I used Knowledge Forum for asking questions and answering questions, but we need to have fun'. This was important feedback for the teacher, as she wanted the students to have a positive and enjoyable experience, especially as there was an element of risk. The discourse in Knowledge Forum was socially attuned to the knowledge-creation model; however, deeper analysis would be required to determine whether it had the epistemic features of knowledge-creation discourse.

Results from Phase 2: The Life Cycles Inquiry Unit

Phase 2 consisted of the life cycles unit and lasted nine weeks. The use of Knowledge Forum was much more extensive during this period. For example, Table 2 shows that the number of notes created was similar to that created during Phase 1, which lasted 20 weeks, and that the numbers of notes read and keywords were substantially higher. The extensive use of keywords reflects the class's practice to identify concepts and vocabulary related to the unit. The social networks (not shown) were similar to those in Phase 1, and students learned how to use some advanced features and created a few reference and rise-above notes, which they used for reviewing what they had learned together from their online work (see the last two rows in Table 2).

To evaluate the student work in Knowledge Forum relative to the knowledge-creation model, we focus in this section on 180 computer notes that were identified to be part of inquiry threads.

The teacher disregarded the remaining notes as unfinished attempts (e.g. if a student could not find a draft note they sometimes started a new one) or brief comments that did not make a substantial point, such as ‘I agree’.

Inquiry threads

Eight inquiry threads were identified: hormones, puberty, plant growth, life stages, old age, reproduction, infancy/childhood, and plant reproduction. These are shown in Figure 4; for each thread the number of notes, authors, and readers are shown in parentheses. Some threads involved most of the students as authors (puberty, plant growth, and reproduction), whereas others involved only a small number of authors. Most of the inquiry threads lasted more than five weeks, which suggests that a number of students remained interested in these topics for some time. The plot also shows 10 ‘bridging notes’—notes that share key words and are considered to address more than one topic (Zhang et al., 2007). Bridging notes can indicate integration across inquiry topics.

[Insert Figure 4 here]

Depth of questioning and ‘scientificness’ of ideas

Figure 5(a) shows that there was a mixture of question types, with nearly twice as many fact-seeking as explanation-seeking questions (50% vs. 27%). There also were many general questions. Lipponen (2000) found that a pedagogical intervention designed to help students develop their questioning skills was very effective, leading to 83% explanation-seeking questions. Zhang et al. (2007), however, found that the ratio of explanatory to factual questions depended on the topic of the inquiry thread. In the present study, the teacher was pleased with the self-directed efforts of students to attain deeper understanding in their first attempt at knowledge creation.

Figure 5(b) shows the results for the 'scientificness' of the ideas. They are promising: taken across the whole inquiry, 46% of the idea units were rated basically scientific or better. Zhang et al. (2007) used a quantitative scale from 1 to 4 to report mean scientificness for the three stages of their four-month inquiry and reported values of 1.93 (Stage 1), 2.46 (Stage 2), and 2.86 (Stage 3). Our result corresponds to a value of 2.44. The existing research indicates that students can improve the scientificness of their discourse by asking more explanation-seeking questions and developing their ideas into explanations, particularly their hybrid ideas (Hakkarainen, 2003; Lipponen, 2000).

[Insert Figure 5 here]

The teacher considered the discourse self-directed (she did not write notes) and progressive. The students gradually introduced higher-level concepts including plant hormones, age-related illnesses such as osteoporosis, and birth defects due to a pregnant woman's unhealthy habits. The ideas went beyond the intended learning outcomes for Primary Five students. This is similar to the finding of Zhang and colleagues (2007) with regard to the discussion of Grade 4 students of light waves, which is a domain in Grade 8 science lessons in the Ontario Science Curriculum.

Sample inquiry thread

To explore how student ideas developed during the inquiry, we briefly discuss the content of one inquiry thread. Thread #2 (puberty) is chosen for analysis because it was one of the longest and was the only one that involved all of the students.

Early in the unit, notes revealed students' questions, ideas from daily experience, misconceptions, and gaps in knowledge of which students were aware. Students tended to describe what they knew without referring to scientific principles. We quote a few representative examples from the first few days of the inquiry thread (all names are pseudonyms).

Randy (April 15): How does the sperm enter the female's property?

Nathan (April 15): The sperm is called the fishy. That is what my mom calls it as a nickname.

Andy (April 15): When the woman kiss the man, the man's sperm goes into her body and change into an egg. They will have a baby inside the egg.

Ben (April 15): The sperms from the male swim and swim to the egg of a female. They transformed into a baby but I don't know how.

Tina (April 18): Once a month, when girls are in their late twenties they empty their bladder just like peeing but this time there is blood. The blood is very dirty so this helps clean the body.

Janice (April 15): The baby grows until it comes out of the mommy's stomach.

The next collection of notes shows that students very quickly corrected misconceptions and introduced information to develop more comprehensive and scientific knowledge. The last two notes are 'rise-above notes' in which students attempted to summarise what had been learned.

Jen (April 15): FEMALES HAVE EGGS NOT SPERM!!!!!!!!!!!

Joe (May 20): Many people love different sex but some can be gay. Gay is not illegal but same sex can't reproduce cause the reproductive systems are the same.

Nathan (May 27): Women produce eggs stored in ovaries and there are trillions of them in each of the two ovaries. After it is fertilised by the sperm, it travels down the fallopian tube to get in the womb not the tummy.

Dan (May 27): The sperm can go into the uterus and combine with the egg. This is called a fertilised egg and zygote. It will grow for about 9 months (same as 40 weeks) in the uterus. There have 300,000 sperms go into female's body. During growth, DNA and cells will explain if you are a boy or girl. Baby inside can also hear music and conversations when their ear systems is fully developed.

Amy (May 27): Reproduction can begin a new life cycle. First part is two people have sexual intercourse.

Ed (May 29): People said the sperm goes into female by kissing but that is not true. It is when the penis of a male touches the vagina of the female.

Tina (May 29): [Putting it all together] A male and female get together and if they really really really like each other, they might have what you call sexual intercourse or flirting. Sperms* from the male will swim through the vagina and penis and into the ovary. But only one sperm will make it unless they're twins, triplets, quadruplets and quintuplets... *Sperms: a tadpole like form that is created in the male. Let's take a closer look at eggs and ovary. The ovary is above the vagina and makes eggs in one area and another for the sperms to come in. When the sperm comes in, the egg and the sperm mix together in the ovary.

Nathan (June 25): [Putting it all together] When the baby is about to be born the mother will feel pain because the baby is kicking inside the uterus so it can come out. When the mother is in the hospital, the baby can come out naturally or operation. I was born naturally and it took 8 hours while my sister only took 1 HOUR!!! When I was watching Inside the Womb on National Geographic, I learned how a baby is made. The fetus was protected by a special fluid called the amniotic fluid. There is a cord attached called the umbilical cord. Each month the female does flush out blood, which means she has menstruation but if she as an egg the blood is flushed away in the vagina.

These notes introduce additional scientific terms including fallopian tube, fertilised egg, zygote, DNA, and amniotic fluid. Many of the notes seem fact based (e.g., 'Reproduction can begin a new life cycle. First part is two people have sexual intercourse' Amy, May 27), whereas others suggest that students understood the information and were explaining it to each other (e.g., 'DNA cells will explain if you are a boy or girl', Dan, May 27). Students did not often mention their sources, but there were notable exceptions (e.g., 'When I was watching "Inside the Womb" on *National Geographic*, I learned how a baby is made', Tina, May 29). Ed's note (May 29) shows how students corrected understanding and helped each other to improve their understanding. Overall, these notes demonstrate that the students introduced considerable information and that their discussion was grounded in scientific phenomena. Elaborations in some of the notes suggest that students were not simply copying and pasting information, but wrote with some understanding of the topic. However, there were few notes suggesting that students were formulating and developing conjectures and theories. 'Let's take a closer look at eggs and ovary' (Tina, May 29) is perhaps the clearest example of the formulation of a conjecture, although it is not stated explicitly. This feature of this inquiry thread is consistent with the substantial focus on *facts* rather *than explanations* revealed by the levels of questions results. The lack of theorising by the children is a clear indication that their work in Knowledge Forum is not quite what is intended with the knowledge-creation model.

Science test

A science content test was given at the beginning and end of the unit. The average score increased from 63.0% (SD 12.6%) at the pre-test to 87.9% (SD 11.5%) at the post-test, a gain of two standard deviations. Although no comparison class was available and this effect cannot be attributed solely to the pedagogical intervention, it surpassed the school's expectation and suggests that the approach was a suitable way to learn this science topic. Unfortunately, although the knowledge-creation approach has been implemented in Western primary schools in a variety of science topics (e.g., heat and temperature, force and motion, flight, electricity, and optics), few studies have examined gains in knowledge of science topics explicitly. One exception is the recent study by Zhang et al. (2007). Clearly more work is necessary to address this question.

Student beliefs and experience

Results from the interviews and questionnaires were positive. Students who were normally quiet during face-to-face discussions said that they found Knowledge Forum beneficial. Because of the sensitive nature of the discussions (physical and psychological changes in boys and girls during puberty), writing online reduced students' embarrassment and their hesitation to share their misconceptions. Henry said, 'I had trouble expressing my ideas about how babies are born and starting questions because it was embarrassing but with so many ideas coming, it was easier for me to join'. Thus, Knowledge Forum seemed to give students opportunities to learn from all of their classmates rather than just those who normally dominate class discussions and projects, illustrating the democratisation of knowledge principle.

Some students also mentioned that there was enough time for them to contribute to the group discussions. Geoffrey said that he felt less pressured to write notes because there was time to read and think about what others wrote. Tina said that it was helpful to have a workspace to work on private notes about puberty, as it give her time to synthesise her theory before publicising it in the database. The 'My Workspace' feature of Knowledge Forum gave students confidence in what they were going to share in the discussions. Students including Angel believed that their classmates were the primary source for help when using the software. This indicates that the effort to establish a supportive and respectful classroom culture in the exploratory phase of the study was beneficial to the community.

Students expressed a shared sense of collective responsibility when reading and writing notes about life cycles. They did not focus on only their own understanding but rather voluntarily explained ideas and responded to questions. Students even shared personal stories about puberty on the database, which supported their theories. For example, some boys said that they were starting to grow facial hair, and some girls wrote about observing older girls in the school developing breasts. Others talked about how they interviewed their parents about their personal experience of pregnancy, puberty, and death in the family. Jen wrote that she brought books with her to the computer lab to start notes on Knowledge Forum. She also used primary sources to critique what others discussed. These last examples show that students were going beyond what they themselves knew, consistent with the principle of the constructive use of authoritative sources.

Conclusion and Implications

This study examined a teacher's first attempt to implement a knowledge-creation approach in a Primary Five classroom in Hong Kong, focusing on classroom practices designed to encourage the discourse required for knowledge creation, and the students' initial work on Knowledge Forum, and ending with the evaluation of a nine-week inquiry unit. The study shows that a teacher can make substantial progress towards enacting knowledge-creation pedagogy within one school year in an Asian context. At the school in which Zhang et al. (2007) conducted their study, the knowledge-creation model was well established as the basis of teaching plans in many classes. In addition, the participating teacher had several years and the students two years of experience with the model. In contrast, in the present study, the teacher had no prior knowledge of the approach, although she did have some exposure to attempts in science education to overcome IRE discourse (van Zee & Minstrell, 1997), and worked in a setting where inquiry-based learning was firmly established. She also built upon the work of Cummings, who reported on the dilemmas he faced in cultivating epistemic agency while addressing the social realities of his classroom and the need for students to develop an accurate understanding of science (Cummings, 2003).

We dealt with some of these difficulties by using the existing practices and school culture as leverages to support knowledge creation. We presented the knowledge-creation approach to the school administration, parents, and children as a new way to address the school's existing goal of inquiry-based learning. We incorporated school goals such as 'finding things out' but cultivated a form of inquiry that involves emergent learning goals and extensive collaboration, and which is more complex than that of the 5E model (Bybee et al., 2006). We made the connections between the values of the new approach and the curriculum explicit through the creation of the knowledge-creation contract, and kept them in focus throughout the school year. Such a contract may be unusual in Western schools. However, at this school, formal agreements of this sort are commonly used, so we used a strategy with which students were already familiar. Overall, there was an interesting mix of teacher and student authority (e.g., introducing the idea of contracts vs. helping students to express their ideas during Quality Circle Time). Although in the West such pedagogical practices may seem inconsistent, in Asian contexts it is less important to resolve the inconsistencies (Lee, 1996). The pedagogy was not 'free-for-all' discovery learning but a fusion of constructivist and instructivist traditions, in which independence and student agency are valued as well as effort and accomplishments. It is proposed that this kind of fusion would also be useful in Western contexts for aligning students' knowledge-creation efforts with external requirements.

The implementation path used in this study differs from the two paths most frequently used by teachers. Scardamalia favours introducing Knowledge Forum at the beginning of the school year.

However, many teachers, particularly those in Asia, prefer to work with their students for many months to develop social and cognitive practices consistent with the model before introducing Knowledge Forum (e.g. Cummings, 2003). Experience from working with teachers suggests that they think that their students are not prepared for dialogue in which students share, test, and try to improve each other's ideas and question the teacher. We used a hybrid of these two paths, in which considerable attention was given to confronting IRE discourse (Mehan, 1979) and developing the necessary social skills, but in which Knowledge Forum was introduced early in the school year. The knowledge wall was used not only to prepare students for Knowledge Forum but also after it was introduced when the computers were not available. There were important interactions between the two modes. For example, students initially treated their notes in Knowledge Forum like private e-mails, but began to understand that their notes could be seen by anyone in the class after reflecting on their experience with the knowledge wall. The teacher did not try to develop a coherent and sustained knowledge-creation inquiry at the outset. Instead, she allowed students to develop the required skills through short-term inquiries that were in the service of the curriculum, and only asked for a more sustained and coherent inquiry approach after five months. This approach made it possible for the teacher to reflect on relatively small amounts of work and to continue to help students develop skills relating to Knowledge Forum throughout the year (e.g., the creation of links between notes and rise-above notes in Phase 2). A commonly observed problem with the use of Knowledge Forum is that both the teacher and students remain frozen in their initial understanding of how to use it and fail to develop its use after the initial introduction.

The literature on the knowledge-creation approach argues forcefully for the de-emphasis of activities and tasks. Scardamalia (2002) contends that a shift similar to the Copernican

Revolution is required from activities at the centre to ideas at the centre. The premise of her argument is that activities are very often treated as ends rather than as means. Thus, when students are asked what they are doing, they say ‘doing an experiment’ far more often than ‘trying to understand why . . .’. Collins (2002) counters that ‘the world of research is, in fact, as much task oriented as it is understanding oriented’ (p. 45). Kolodner et al. (2003) ‘ritualise’ activities such as poster presentations and gallery walks as part of their efforts to create the classroom ethos needed for Learning by Design™. Students become familiar with these activities, understand why they are necessary, and expect them. This does not mean, however, that the activities become mindless or ends in their own right; rather, they reify cultural norms and provide ways for the class to get its work done. Accordingly, the point of the contract was not just to review the IB Learner Profile or make an agreement, but to gain understanding of how knowledge creation is related to the IB Learner Profile and to obtain a material resource for keeping this understanding in focus throughout the class’s work together. The QCT was how the class talked *when it had something to talk about*. Many practices in addition to those discussed in the present study are needed to support knowledge creation, especially ones that can help students make sense of where their ideas are taking them.

We do not want to suggest that this was a particularly strong example of knowledge creation, only that the teacher was able to make substantial progress in this direction. As mentioned earlier, work in Knowledge Forum should be oriented more towards explanations and idea improvement than we were able to accomplish, and students did not suggest activities to investigate emerging questions (e.g. experiments, as in Zhang et al., 2007). During interviews with students, we would also expect signs of epistemological understanding, such as the use of phrases including ‘I still don’t understand why . . .’ and ‘my hypothesis was wrong’. If teachers are to use student experience in knowledge creation as a context for teaching them about the nature of science, then such meta-knowledge is undoubtedly needed. Neither do we suggest that we eradicated IRE discourse in this class. Nevertheless, we think that what the teacher was able to accomplish in this first-year implementation surpasses previous published attempts.

The study was conducted in a setting where inquiry learning and dialogue were already valued and practiced; this is the case in primary schools that follow the IB PYP curriculum. Therefore, important next steps are to try to replicate and extend the study in similar and other settings. It would also be useful to examine the diffusion of knowledge advances through the community, and growth in epistemological understanding.

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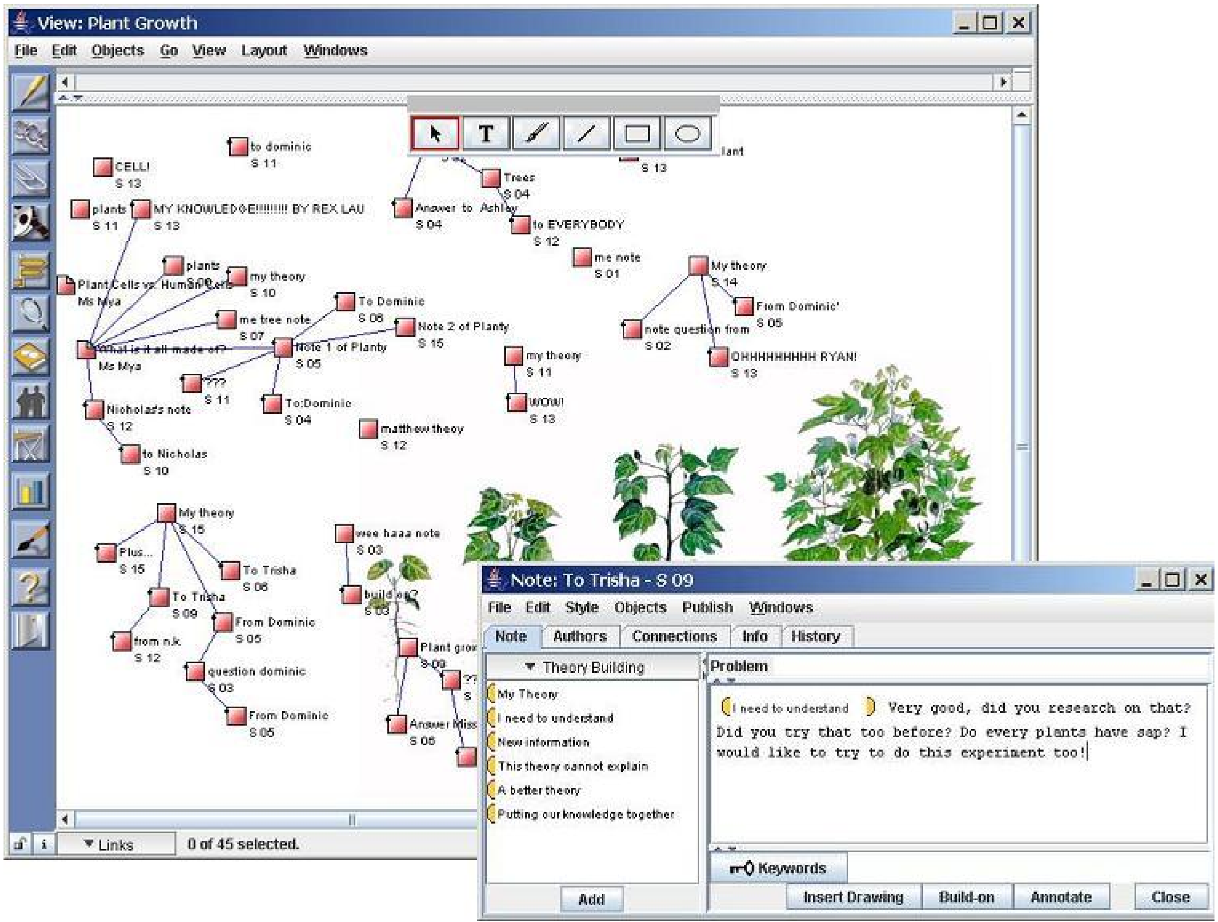


Figure 1: Knowledge Forum The large window shows the various tools and the 'Plant Growth' view; the squares are note icons and lines between note icons indicate that one note is a direct response to another. The partly hidden diagram with plants of different sizes shows how the background of the window can be used to arrange the notes conceptually (in this case making plant growth visible). The small window shows a note, with a menu of scaffolds on the left and the note content on the right.

PHASE 1: EXPLORATION (20 weeks)

RQ1: How useful are the activity structures in supporting knowledge building to a group of students who had no prior experience with knowledge building or Knowledge Forum?

Classroom (more emphasis)	Knowledge Forum (less emphasis)	Other
Describe classroom activities: video recordings, photographs, field notes, teacher reflections, Knowledge Wall, KC contracts	Assess overall participation and social structure: notes created, notes read, social networks	Collect student opinions: students' written reflections

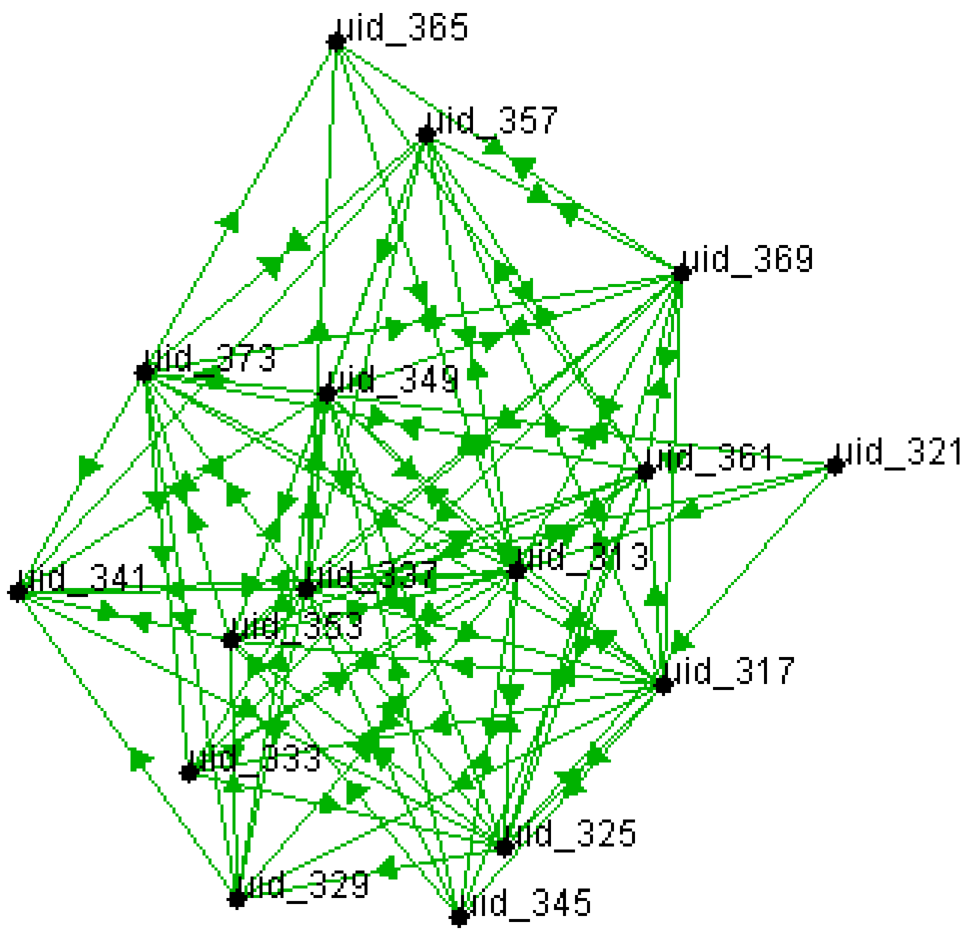
PHASE 2: EXTENDED INQUIRY (9 weeks)

RQ2: To what extent is there Knowledge Building in students' discourse during their life cycles studies?

RQ3: What are students' beliefs and feelings about the quality of their discourse on Knowledge Forum?

Classroom (less emphasis)	Knowledge Forum (more emphasis)	Other
Describe classroom activities: video recordings, photographs, field notes, teacher reflections	Identify inquiry threads Statistical analysis: levels of questioning, levels of explanation, social networks within inquiry threads; justification of claims by data or experience; introduction of authoritative sources Qualitative features: analyze largest inquiry thread on four principles	Collect student opinions: students' written reflections, questionnaire Assess content knowledge: pre-post science test

Figure 2 Overview of data collection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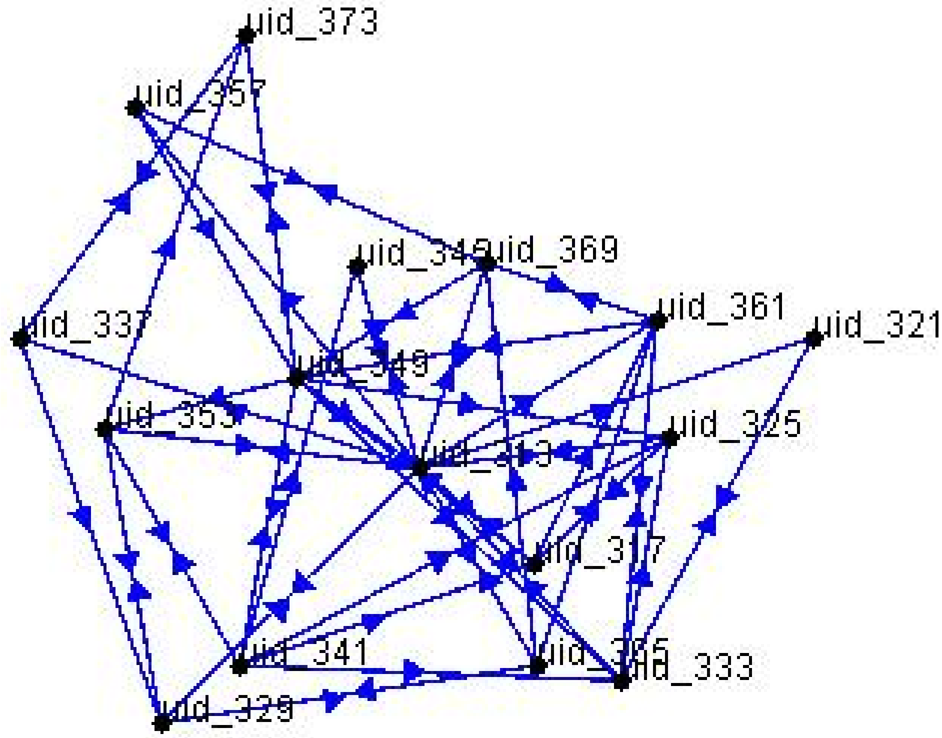
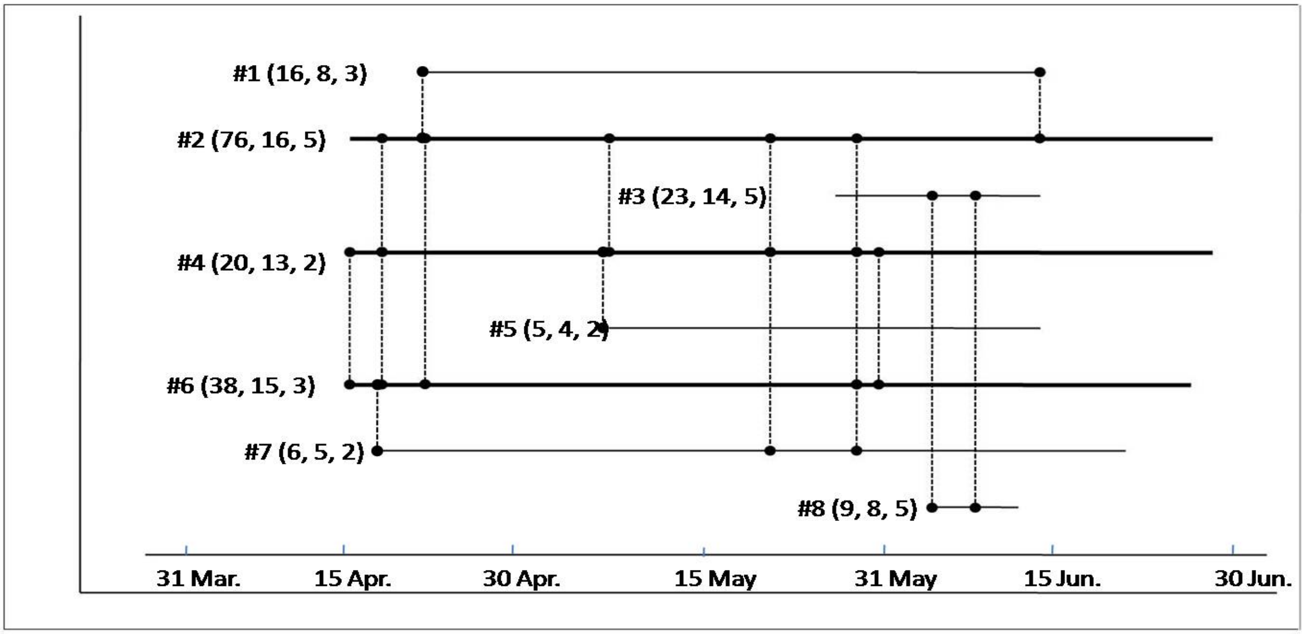
(a) Reading



(b) build-on

Figure 3: Social networks for Phase 1 (a) Reading – each link indicates that the person at the tail of the arrow has read at least five notes written by the person at the head of the arrow. In this network, 100% of the links that are possible are realized. (b) Build-on notes (responses) – each link indicates that the person at the tail of the arrow has built on (responded to) at least three notes written by the person at the head of the arrow. 34% of the links that are possible are realized.



Legend:

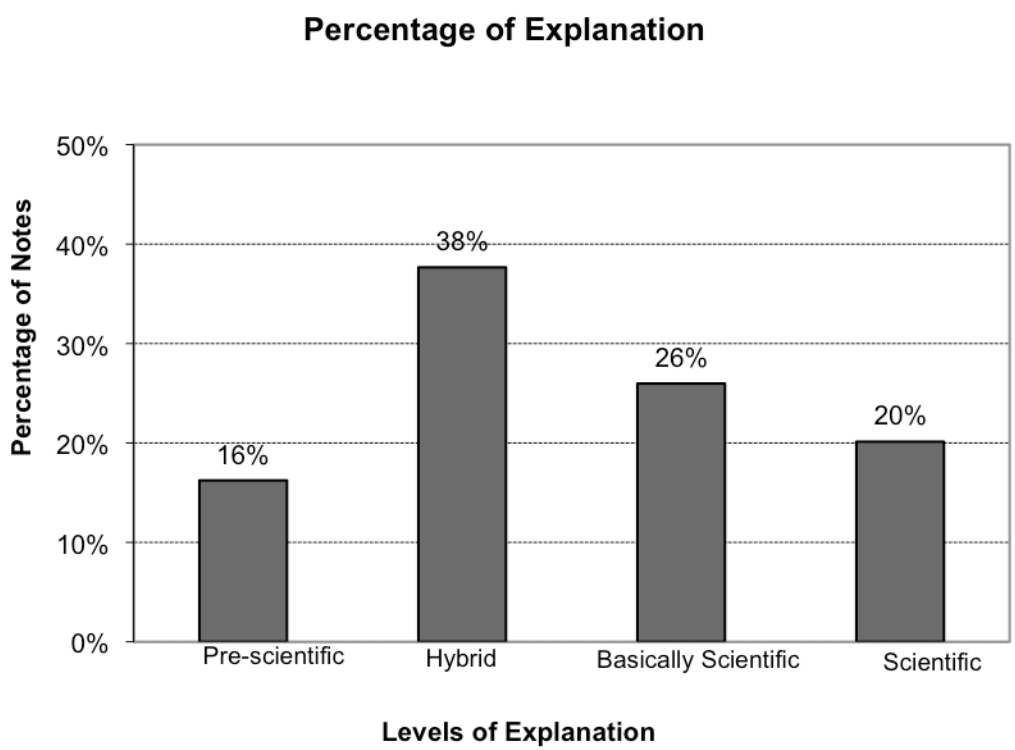
#1 Hormones/Changes; #2 Puberty; #3 Plant Growth; #4 Life Stages
#5 Old Age; #6 Reproduction/Pregnancy; #7 Infancy/Childhood; #8 Plant Reproduction/Seeds

— Inquiry thread

Shared notes across threads

The number following the code and title indicate the number of notes, authors and average readers, respectively

Figure 4: Inquiry Threads



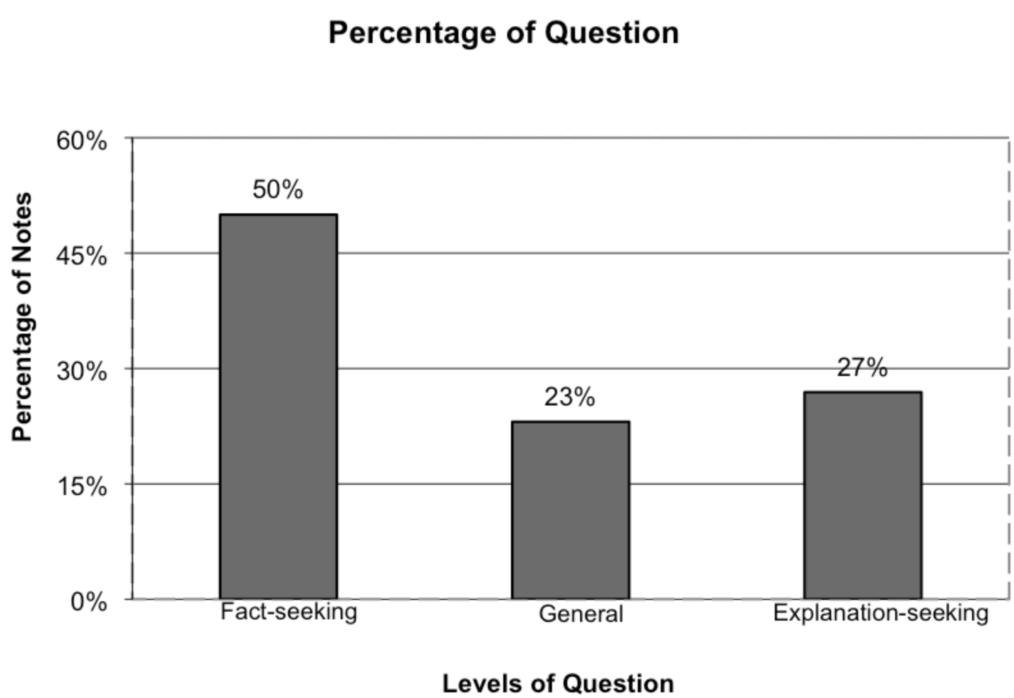


Figure 5: Levels of explanations and quesitons

Table 1

Knowledge Building Contract Summary

Learner Profile	Students Brainstormed Ways They Can Demonstrate the LP in KB Activities and Discussions
Inquirer	Ask questions, provide explanations, take notes
Knowledgeable	Research questions, share resources such as books, videos, models and photos
Thinker	Reply to questions, ask questions, give reasoning, gather information
Communicator	Read and write notes and reports, do presentations, add to discussions, translate information to English for discussions, conduct interviews
Principled	Don’t use other people’s KF passwords, don’t write bad words, don’t make fun of other people’s spelling, grammar or ideas, take care of the computers
Open-minded	Listen and read each other’s theories, find information from different places and not just from books or the Internet
Caring	Help each other out, share ideas, be patient with the computers, take care of the computer lab
Risk-takers	Participate in class discussions and the forum, share ideas, question other people’s theories, go out to find information, interview people
Balanced	Don’t always use the computer, use different sources for research, contribute to discussions regularly
Reflective	Write reflections in the unit notebook and forum, participate in discussions, evaluate information, edit notes, summarize discussion notes

Table 2

Mean (SD) Indicators of Participation

	Phase 1 (Exploration) Oct. 31 2007 to March 31 2008		Phase 2 (Main Inquiry) April 1 to June 25, 2008	
	M	SD	M	SD
Notes created	33.3	14.8	32.4	14.9
Build-on Notes	26.6	15.8	23.2	13.3
Notes Read	102.8	40.6	133.1	49.6
Keywords	20.5	20.5	55.2	30.4
Reference notes	-	-	1.81	1.47
Rise-above notes	-	-	0.88	0.34