EXPLORING PARTICIPATION IN KNOWLEDGE BUILDING: AN ANALYSIS OF ONLINE DISCUSSIONS IN MAINSTREAM AND HONOURS SOCIAL STUDIES COURSES

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ABSTRACT

Some new instructional approaches that emphasize inquiry involve asynchronous online discussions, but many teachers question to what extent most students in a class participate in such discussions. This thesis examines this issue in the context of knowledge building, drawing from two implementations of the same inquiry unit conducted by students from a mainstream and an honours version of a tenth grade social studies course (N = 100). In each implementation, students collaborated in small groups to propose solutions to current environmental problems. The research questions focused on participation patterns as revealed by server log data, the extent to which the discussions could be considered examples of knowledge building, and the influence of several moderating variables on participation. Findings indicated there was substantial evidence for knowledge building in all classes; differences for participation measures were stronger between collaborative groups than between mainstream and honours classes.

Keywords: online discussion, CSCL, knowledge building

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GLOSSARY

ANOVA	Analysis of variance
ATK	Analytic Toolkit
BC	British Columbia
CSCL	Computer supported collaborative learning
CSCW	Computer supported collaborative work
CSILE	Computer supported intentional learning environment
EQ	Epistemology Questionnaire
ESL	English as a Second Language
HRSDC	Human Resources and Skills Development Canada
IRP	Integrated Resource Package
KB	Knowledge building
KF	Knowledge Forum
MANOVA	multiple analysis of variance
SES	Socio-economic status
SFU	Simon Fraser University
WAT	Writing Apprehension Test

CHAPTER 1: INTRODUCTION

In the last two decades, there has been much interest in collaborative inquiry as an educational goal (National Research Council [NRC], 1996), and a new field, computer supported collaborative learning (CSCL), has emerged. The CSCL field focuses on the development and study of technology-enhanced approaches to collaborative inquiry. Some examples of approaches within this field are: LOGO (Papert, 1980; 1993); the Adventures of Jasper Woodbury (Cognition and Technology Group at Vanderbilt, 1992); knowledge building (Bereiter & Scardamalia, 1993); CoVis Collaboratory Notebook (Edelson, Pea, & Gomez, 1996); Learning by Design (Kolodner, 2002; Kolodner, Crismond, Gray, Holbrook, & Puntambekar, 1998); ThinkerTools (White & Fredericksen, 1998); and Web-based Science Inquiry Environment (WISE; Linn & Hsi, 2000). Despite sustained effort to develop technologies and teaching approaches, the large-scale implementation of the various approaches has remained an important challenge (Fishman, Marx, Blumenfeld, Krajcik, & Soloway, 2004; Rogers, 1995).

One problem is that although most CSCL approaches have been developed in classrooms typical of schools in general in terms of socio-economic status, the range of achievement, interest, and motivation, many teachers remain unconvinced that most students in their classes can participate in and benefit from the new approaches. This thesis explores one aspect of this problem:

participation in asynchronous online discussions. The context in which the problem is investigated is knowledge building, which is introduced in the next sections.

Knowledge Building: A Preliminary Description

The following vignette describes an example of knowledge building (Bereiter & Scardamalia, 1993; Scardamalia & Bereiter, 2003), in which a ninth grade class is studying the topic "water quality" over a period of approximately six weeks. All the features of the vignette have been implemented, but not in the same context. I use this vignette to provide a preliminary description of knowledge building, on which I elaborate in Chapter 2.

> Fuelled by recent news reports of problems with drinking water in several communities, a ninth grade science class has become interested in the water quality in its own local community. The class begins by immersing itself in the topic by gathering and studying relevant documents such as news reports, technical reports of studies of water quality, and published standards for water quality. The teacher has vetted some of these sources. As they study, students enter notes into a database—a web-based discussion forum. In this database, students begin to build a record of the class's ideas questions. After some time, groups of students summarize the class's collective ideas, puzzlements, and interests, and present these summaries to the class. By now, the class has some understanding about how water quality can be measured, the biological implications of poor water quality, factors that influence water quality, and the extent to which these can be controlled. Students see that defining, measuring, and maintaining water quality are complex. Some students have noted that in Canada there is usually a trade-off between maintaining water quality and economic growth; others pointed out that in the developing world it is the

other way around and economic development seems contingent on improving water quality. A *field of inquiry* has opened up in the class, which reaches far beyond the initial interest in local water quality.

As the class's work continues, different students work on different projects. Some students decide to focus on measuring water quality. They study relevant physical concepts, design experiments, master experimental techniques, and collect and analyze data in the local community. Other students research what is known about the state of water quality around the world. Yet others research the ecological implications of poor water quality. In all projects, progressive problem solving occurs: Inquiry is not just finding out the answer, but involves an iterative process where understanding at one level leads to new questions and new ideas for inquiry. Further, although each student works directly on only a small number of projects, students keep their eyes on advancing the state of knowledge in the class as a whole. A specific project derives its significance from how, together with other projects, it leads to a coherent and reasonably comprehensive understanding of the topic water quality within the class. Skill at analyzing water quality is accompanied by deep understanding of violations of local standards that are most likely to have significant environmental impact, how the water quality could be improved, and counter-arguments that could be made to the proposed solutions on economic grounds. One might say that the whole is greater than the sum of the parts.

The database continues to play an important role throughout these projects. Students open up new spaces for discussing problems, preliminary findings, and emerging questions. As students try to explain their ideas to collaborators, they often find that they do not understand them well enough and revise them. Collaborators help each other by

testing ideas, offering new points of view, or offering new examples that render an idea more persuasive. When a group feels that it has made some progress on a problem, it presents the idea in a format that can also be understood by students who have not worked on it; they provide enough background to the idea and explain how they think it advances the class's knowledge. Now a new cycle of critique begins, in which the class as a whole seeks to understand if and how a new idea advances the class' understanding of water quality. At this stage, the ongoing record of ideas in the database becomes useful for sorting out how a new idea has improved on previous ideas. As new ideas become more generally known throughout the class, students in groups other than the one that originally developed them begin to use them. At the teacher's suggestion, students map the learning outcomes onto the prescribed learning outcomes from the Ministry of Education.

*

Implementations of knowledge building can vary considerably from this vignette. However, most implementations share the following features:

1. Students work on complex problems that in general do not have agreed-upon solutions and that are of interest to them
2. The work students do individually or in groups is framed by a *collective goal* to advance the state of knowledge in the class
3. Students study previous work on a problem but use what they learn this way to build knowledge that is new to the class
4. Students do not only use instructional materials designed for their own educational level but use whatever available and relevant resources they can understand
5. Students identify gaps in the class's understanding, plan their own learning paths, and evaluate progress

6. Discourse, including discourse mediated by web-based discussion forums, plays an essential role in improving the ideas the class is using as well in evaluating collective knowledge advances

Why Knowledge Building?

Advocates for knowledge building assert that it is an important 21st century skill (Bereiter, 2002; Scardamalia & Bereiter, 2003). Here I briefly mention three arguments. First, as one can infer from the above list, knowledge building involves an advanced epistemology. Studies of epistemological belief have shown that children, adolescents, and even young adults view the knowledge of experts as certain and authoritative, and learning as the quick take-up (assimilation) of new information (e.g., King & Kitchener, 1994; Schommer, 1990; Schraw, Bendixen, & Dunkle, 2002). By contrast, the epistemology of knowledge building emphasizes that knowledge is not certain and authoritative but in principle subject to refutation and improvement, and that learning is effortful and involves discourse.

Second, in knowledge building students have substantial responsibility for the learning process; they execute tasks such as identifying gaps in the class's knowledge, planning, and monitoring progress, that are typically executed by the teacher (see item 5 on the list). Scardamalia (2002) refers to this as *epistemic agency*. In an era in which information is easily available via the internet and accumulates rapidly, the ability to locate information, evaluate its merit and relevance, and use it to build knowledge needed for specific purposes, is of vital importance (Bereiter, 2002). In addition, it has been argued recently that

graduates from secondary schools are not adequately prepared for the level of independence required for post-secondary education. Therefore, several recent curriculum reforms have been designed to foster more independence from the teacher—*learning how to learn* (e.g., Education and Manpower Bureau [EMB], 2000).

Third, although many educational approaches that fall under the umbrella of social constructivism involve cooperation and collaboration, knowledge building is unique for its emphasis on *collective knowledge advancement* rather than only personal knowledge advancement. This feature of knowledge building is analogous to being results-focused in the workplace. Writing about leadership teams in companies, Lencioni (2002) argued that all members of such teams need to be committed to attaining agreed-upon goals. Thus knowledge building may help to foster advanced epistemological belief, learning how to learn, and social skills needed for collaboration focused on shared goals (van Aalst, 2006).

Barriers to Knowledge Building

Becoming a teacher who encourages knowledge building involves an epistemological shift and rethinking of student and teacher roles, and currently little information is available to address the concerns teachers raise. This state of affairs has given rise to a set of *barriers* to knowledge building. Although teachers frequently accept the theoretical value of knowledge building, they say that knowledge building is too difficult to carry out in practice (van Aalst & Hill, 2001). When they attempt to implement knowledge building, there is a tendency to provide too much structure and management of activities. This can

compromise essential characteristics of knowledge building such as epistemic agency. There also are concerns that misconceptions will occur during knowledge building and that what students will learn is incorrect. Knowledge building is also in conflict with the belief of "learn first, produce later," which implies that creative work can only occur after a long time of learning existing knowledge. Below, I describe three common teacher assumptions that are barriers to large-scale implementation of knowledge building.

1. "*Knowledge building will only work with certain students, but not with most students in a typical class.*" Teachers often say that *some* of their students could participate in, and benefit from, knowledge building. However, they doubt that most of their students can. Some examples of this are provided by a study by van Aalst and Hill (2001), which examined teachers' experience with knowledge building in an in-service course focusing on inquiry in science education (pp. 4-9):

> "...the biggest thing is actually having it (knowledge building) in a group of 30 students where you have everyone engaged and excited about it."
>
> "only a few (students) participate...because they are good at the language thing and thinking on their feet and thinking quickly and they have lots of prior knowledge."
>
> "I find that my boys, other than one or two girls, really are much more into the science, unfortunately."

There is also considerable anecdotal evidence that teachers are willing to consider knowledge building as an extra-curricular activity or for gifted students.

2. *"Knowledge building is too difficult to integrate with the curriculum."* Knowledge building takes more time than conventional teaching, and teachers question whether students will be prepared adequately for external exams and future learning. Although many teachers assert that their teaching is based on principles of constructivism, the content-driven curriculum exerts pressure on teachers, who say they feel "bound by the curriculum" (van Aalst & Hill, 2001). Teachers must cover the main topics so that "the next year's teacher doesn't curse you" (p. 6). In the upper years of secondary schools, external exams and focus on grades also put constraints on knowledge building. In most educational systems, students are rewarded for focusing their efforts on the completion of tasks to certain standards rather than the desired learning that provides the rationale for these tasks (Bereiter & Scardamalia, 1993; Scardamalia & Bereiter, 2003).

3. "*The fate of misconceptions is uncertain.*" When students discuss their ideas, misconceptions become apparent. Teachers raise concerns these may become prominent in student thinking because they have been brought to the foreground and have not been addressed adequately. Teachers feel that they are taking risks that if a statement made by the students is incorrect, it may interfere with subsequent learning. One of the teachers interviewed by van Aalst and Hill (2001) stated, "You'd really have to watch for misinformation. There would be some people that would just contribute...I don't know, they would just contribute ideas things that they heard all the time which might lead to misconceptions, or would lead, in many cases" (p. 5).

Although the interest in this thesis is in knowledge building, concerns like these are not unique to knowledge building. Generally, an innovative approach is likely to meet these objections. The resistance may come from any actors of the educational system, especially the teachers.

Focus and Research Questions

The objective of this thesis was to explore the first of the above-mentioned three concerns: Can most students in a typical secondary school class **participate** in online knowledge-building discourse? This question arose during a workshop for teachers who were implementing knowledge building at the same secondary school. Several teachers at the workshop observed that there were considerable differences in the online discussions by students in mainstream courses and honours courses at the same grade level. In particular, students in the mainstream courses created fewer notes (i.e., contributions), and the discussions themselves had fewer notes.

The question is important because advocates of knowledge building argue that knowledge building is a mode of learning that is accessible to a wide range of learners; Scardamalia (2002) refers to the "democratization" of knowledge. For example, students may improve their ideas when they respond to comments from peers, raise additional or opposing viewpoints, provide examples, or ask for clarification (Scardamalia, 2002; van Aalst, 2006). If some students create relatively few notes, or their notes are not taken up by peers, they have limited opportunity to improve their ideas this way.

The thesis investigates the following research questions:

1. To what extent do students in mainstream and honours social studies courses participate in online knowledge building discussions?
2. How do participation levels vary across groups of students who are collaborating, disregarding which in which class students in a group were enrolled?
3. Do the online discussions in both courses resemble knowledge-building discourse?
4. What relationships exist between participation in online knowledge building discussions, writing apprehension, epistemological belief, and portfolio ratings?

The first research question arose from the teachers' observations. However, the mainstream-honours distinction is difficult to interpret conceptually. Students are typically placed in mainstream and honours courses on the basis of grade-point averages and teacher recommendations. Grade-point averages are generally influenced by a range of variables: motivation, interest, prior academic success, study skills, intelligence, encouragement from teachers and parents, appropriateness of the teaching method to the individual students, peer pressure, highest educational level of parents, income level of parents, and so forth. There is much research showing the influence of each of these variables on grade-point averages (Gutman, Sameroff, & Cole, 2003; Kobrin, Milewski, Everson, & Zhou, 2003). Thus, the mainstream-honours distinction is a general distinction that involves a combination of these variables. Nevertheless, it is an important distinction to consider because it is central to the organization of many schools. Whatever the exact nature of the distinction, teachers seem to think about such

issues as expected outcomes and student agency differently depending on the academic level of the course.

One indication that the picture is more complex than the mainstream-honours distinction suggests was provided by an informal study of online discussions. Whiffin (2003) compared discussions from two instructional units in a grade twelve English course and concluded that the *nature of the task* influenced the length of the discussions. One would also expect that if groups *collaborate* on problems, there could be differences in the approaches used to collaborate, and these could produce very different participation patterns in online discussions. Consequently, with the second research question I examined variation in participation between groups that collaborated. It was hypothesized that differences in participation between groups could be substantial—possibly even larger—than differences between classes. The third research question examines online discussions qualitatively as possible examples of knowledge building discourse. The final research question explores several independent variables that may be related to participation.

Study Context

The thesis investigates the research questions in two successive implementations of a short collaborative inquiry unit focusing on environmental problems in grade ten social studies courses. The first three research questions are studied in both implementations and the fourth only in the second.

The school was located in an urban community with socio-economic status (SES) indicators somewhat above average for British Columbia. In each implementation, the same teacher concurrently taught mainstream and honours versions of the grade ten social studies course. The teacher was experienced, but was new to knowledge building and the use of online discussions at the time of the first implementation. Although there were some differences between the two implementations, the following features of the instructional design were constant across implementations:

- The teacher provided a list of general environmental problems, which he judge to be of current local interest and which did not have widely accepted solutions
- The teacher directed students to form groups of approximately eight students from their own class to investigate one of these problems, based on their interest in that problem
- Each group used the internet and other available resources to research its problem, and discussed the problem in its own discussion space in Knowledge Forum, an asynchronous networked discussion environment (see Chapter 2)
- Each class worked on Knowledge Forum™ in a computer lab once per week, but most of the work on Knowledge Forum was done after class using home computers and computers in the library
- Student evaluation was based on a portfolio of their learning, in which students discussed several notes from Knowledge Forum that they felt made important contributions to their group's discussion and summarized their learning
- The total instructional time devoted to the project was three weeks

There also were some important differences between the two implementations. 1) At the time of the second implementation the teacher had a better understanding of knowledge building and how to encourage it. 2) The researcher requested more similar guidance of the students in the mainstream and honours classes. 3) Whereas during the first implementation each class used its own Knowledge Forum database for online discussions, the two classes shared a database during the second implementation and the teacher encouraged students in the mainstream class to read, but not comment on, some of the discussions by the honours class. These changes are discussed in more detail in Chapter 4.

Overview of the Thesis

The thesis is organized as follows. Chapter 2 provides an overview of knowledge building and tools available for evaluating knowledge building discourse. Chapter 3 provides a rationale for quantitative methodology and presents the analysis of the first implementation. A description of the methods, teacher and participants, curriculum, data collection, data analysis, and limitations of the study are also presented. Chapter 4 presents the second implementation, using a similar format. Chapter 5 provides a general discussion of the findings from both implementations and their implications for further research and practice.

CHAPTER 2:
KNOWLEDGE BUILDING

This chapter provides the conceptual background for the thesis; it consists of five sections. The first section provides an introduction to the field of computer-supported collaborative learning (CSCL) to provide more theoretical context for the knowledge building research program. The second section provides a theoretical description of knowledge building, elaborating on the informal description provided in Chapter 1. The third section describes Knowledge Forum™, a networked discussion environment uses in many implementations of knowledge building. The fourth section reviews existing studies of knowledge building. The final section describes two tools for analyzing knowledge building: the Analytic Toolkit (Burtis, 1998) and Scardamalia's (2002) knowledge building principles.

Computer Supported Collaborative Learning

In 1996, Koschmann described computer supported collaborative learning (CSCL) as a newly emerging "paradigm" of instructional technology in parallel with other educational paradigms like computer assisted instruction (CAI) and intelligent tutoring systems (ITS). CSCL is defined as collaborative learning supported by technology that can enhance peer interaction and work in groups. It involves collaboration and technology that facilitate sharing and distributing knowledge and expertise among community members (Lipponen, 2002).

Since the first CSCL workshop held in 1991, research has been done in this field to advance the theoretical and empirical understanding of CSCL. Two influential books reviewed progress. *CSCL: Theory and Practice* (Koschmann, 1996) was based on a selection of papers from the 1995 CSCL conference and helped to broaden the discussion of CSCL to include additional (especially theoretical) perspectives. The second book, *CSCL 2: Carrying Forward the Conversation* (Koschmann, Hall, & Miyake, 2002), consisted of experimental studies and implementations of CSCL approaches in educational settings. This book also explored issues such as technology support for collaboration, and theories underlying design.

CSCL approaches are based on social constructivism, highlighting individual and distributed aspects of cognition (Salomon, 1993), and often involve writing into a computer-supported asynchronous discussion environment; the environment is often a discussion board. CSCL environments embody particular theories of learning and instruction. Studies of CSCL have examined a wide variety of learning effects, including conceptual change, depth of inquiry, and metacognition (Linn & Hsi, 2000; Lipponen, 2000; White & Fredericksen, 1998). Evidence thus far suggests that CSCL is a promising possibility for increasing the quality of education, using modern information and communication technologies (Lehtinen, Hakkarainen, Lipponen, Rahikainen, & Muukkonen, 1999; Roschelle & Pea, 1999). In the next three subsections I describe three specific approaches in CSCL to provide some examples of research programs in CSCL.

Logo

The Logo programming language was created as the first children's toy with built-in computation. It has been developed over the past three decades. Logo was designed as a learning tool for children, but is now used in educational settings from kindergarten to university. Logo is founded on constructionist philosophy, which differs from constructivism. Constructionism "looks more closely than other educational -isms at the idea of mental construction. It attaches special importance to the role of constructions in the world as a support for those in the head, thereby becoming less of a purely mentalist doctrine" (Papert, 1993, p.143).

The most popular Logo environment involves the Turtle, which was originally a robotic creature that moved around on the floor. Then the turtle migrated to the computer screen and lived as a graphics object. Students type commands at the computer and make the turtle move around so that it draws shapes, designs, and pictures.

Logo was designed based on the goal of allowing teachers and learners to use and manipulate computers in more familiar manner than numbers and equations such as graphs and "talking to the turtle" (inputting commands to make the turtle move). Additionally, when practicing Logo, learners' thinking process is valued. In Logo, it is more interesting and educational to look at how a design was created than to look at the design itself. Logo teaches problem solving, logical thinking, constructive methods and allows learners to interact and collaborate during creating and manipulating mathematical processes. Logo is

easy for novices to access, including young children, and also supports complex explorations and sophisticated projects by experienced users (Papert, 1980).

Learning by Design

Learning by Design is a project-based inquiry approach to science education for grades six to eight students. Learning by Design builds on many cognitive theories that address learning (e.g., case-based reasoning, constructivism) and classroom practices, which support collaborative learning and learning from hands-on activities (e.g., Problem-Based Learning, communities of learners; Kolodner, & Nagel, 1999). In Learning by Design, computer software is used to help students organize their thoughts into logical subjects and keep them on the right track of the subject at hand. The software is a web application, so that students and teachers will not only have access to ideas coming from their own class, but also ideas from a larger community of all the classrooms using the Learning by Design system over time.

The goal of Learning by Design is to promote the development of inquiry-based science classrooms in contemporary school settings. Students learn science content and skills in the context of achieving design challenges. Such design challenges provide opportunities for students to engage in and learn complex cognitive, social, practical, and communication skills (Kolodner, 2002). In Learning by Design projects, students iteratively reflect upon their hands-on experiences, investigating, redesigning, testing, and analysing results of their ideas to achieve design challenges as scientists and engineers do (Holbrook & Kolodner, 2000). In Learning by Design classes, students learn the designated

science as well as or better than their peers in traditional settings. They also learn science process skills, collaboration, communication, and planning skills.

Web-based Inquiry Science Environment (WISE)

Web-based Inquiry Science Environment (WISE) is an online learning environment, in which students examine real-world evidence and analyze current scientific controversies such as genetically modified foods and water quality (Linn, Clark, & Slotta, 2003). WISE projects are designed to meet the National Science Education Standards (NRC, 1996) for grade four to twelve students. They provide opportunities for students to reflect on material they may have covered in class but have not yet applied in relevant ways. Special WISE software guides students through web pages that provide content, which encourages reflection, data visualization, causal modeling, simulations, online discussion, and assessment. Students practice scientific reasoning and gain important perspectives on the nature of science by taking notes, critiquing and comparing theories, and organizing their arguments. Features of the WISE environment such as the *Our Teacher* area also help teachers explore new projects and grade students' work on the Web. Research shows that students who engage in WISE projects demonstrate reliable learning gains, as measured by assessments that reflect both content and process standards (Linn, Clark, & Slotta, 2003).

Knowledge Building

In Chapter 1, I described knowledge building informally using a vignette; I now elaborate on that description. Knowledge building is an important strand in the field of CSCL; in *CSCL 2: Carrying Forward the Conversation*, an entire

section was devoted to knowledge building. The term 'knowledge building' is now used widely in CSCL and knowledge management.

Origins of Knowledge Building

Bereiter and Scardamalia's notion of knowledge building emerged from their prior research on the writing process (Bereiter & Scardamalia, 1987; Scardamalia, Bereiter, & Lamon, 1994), intentional learning (Bereiter & Scardamalia, 1989), and expertise (Bereiter & Scardamalia, 1993; Scardamalia & Bereiter, 1994).

In their research on the writing process, Bereiter and Scardamalia distinguished two models of writing: knowledge-telling and knowledge-transformative. In the former, writers transfer their ideas to written form; in the latter, writers realize during the writing process that the ideas they are attempting to communicate themselves need revision (Bereiter & Scardamalia, 1987). Thus, knowledge-transformative writing is not just communication; it is a constructivist process that contributes to students' understanding; it is consistent with belief of learning as effortful (as opposed to the quick uptake of information), and of ideas as improvable. Another important idea contributing to the development of knowledge building was *intentional learning* (Bereiter & Scardamalia, 1989), according to which learning is an intentional act. That is, Bereiter and Scardamalia viewed learning, as typically observed in schools, as a *by-product* of activities, and argued that it should be a *central goal.* Scardamalia (2002) likened the educational shift needed to the Copernican revolution—from an educational worldview with *activities* at the centre to one with *ideas* at the centre. Thus, for

example, instead of saying "I am answering questions about this chapter" (reflecting a focus on task-completion), students should be saying that they are trying to understand the causes of World War I. An important aspect of intentional learning is that students have agency over the learning process, especially over planning, monitoring, and its execution. Driven by a goal to understand the causes of World War I, students may take the initiative to study available texts and devise a method for evaluating if their understanding is improving.

In the mid 1980s, Scardamalia and colleagues began developing a computer-supported communal database system to support knowledge-transformative writing and intentional learning; the first generation was called CSILE (Computer Supported Intentional Learning Environments; Scardamalia, Bereiter, McLean, Swallow, & Woodruff, 1989), and the current generation is Knowledge Forum. Students contribute ideas to the communal database; peers who have access to the database can comment on these, and students can revise their ideas based on such comments and their own reflection. Within CSILE notes, "thinking types" (a pre-defined set of sentence starters) were available to help students maintain focus on the knowledge-transformative mode of writing and intentional learning, rather than the more common writing mode of knowledge-telling. For example, by using the thinking type *planning*, students announced that the content of the note would be a plan of some kind; by using the thinking type *my theory* students indicated that the information should be subject to scrutiny, testing, and perhaps improvement.

Additional important ideas contributing to the development of knowledge building arose from Bereiter and Scardamalia's (1993) study of expertise in a variety of domains. Unlike previous authors, who based the study of expertise on novice-expert comparisons (Chi, Feltovich, & Glaser, 1981; Hardiman, Dufresne, & Mestre, 1989), Bereiter and Scardamalia posited expertise as a *process*. They asked why many experienced practitioners, despite having similar training, experiences, and opportunities as experts, are not regarded as experts by their peers. Bereiter and Scardamalia argued that people on a path toward becoming experts engage in processes such as 'progressive problem solving', in which they reinvest cognitive resources in new learning once they understand a problem at one level (i.e., one question leads to additional questions). By contrast, experienced non-experts frequently constrict a problem to one they can manage or may be satisfied with superficial understanding. Bereiter and Scardamalia (1993) argued that although children in elementary school clearly know less than experts, they could be considered expert-like if they use the processes people on their way to expert knowledge use for new learning. They provided evidence that children are capable of such processes (Bereiter, 2002; Bereiter & Scardamalia, 1993). Bereiter and Scardamalia's research on writing was important because writing was an *example* of the process of expertise that could be understood using research over several decades on cognitive psychology; their research on expertise took knowledge building from a perspective with relevance for literacy development to one relevant to the

development of expertise in a variety of domains, especially science, mathematics, and social studies.

Over time, *collaboration* and *community* became more important to knowledge building, especially after the introduction of the Internet into education in the mid 1990s. Initially, it was recognized that students could comment on each other's writing in a communal database (Scardamalia et al, 1989), and that such comments could help students revise their ideas. Thus knowledge-constructive writing became a collaborative endeavour. When the Internet became available, it was no longer necessary to limit collaborative partners to a single class of students. For example, van Aalst and Chan (2001) documented how two distant graduate classes shared a Knowledge Forum database and collaborated to generate deeper understanding of the literature. It is also possible to link experts to projects, who can provide advice to students (O'Neill & Gomez, 1998). In addition, the Internet provides informational resources that make open-ended inquiry projects more feasible.

The Educational Vision

Knowledge building is an innovative educational approach that aims to make the process of expertise central in schools. However according to Scardamalia and Bereiter (1996), traditional schools are not designed to foster expertise. Specifically, school tasks and individual abilities are the centre of schooling (Bereiter & Scardamalia, 1993; Scardamalia & Bereiter, 1996). According to these authors, in classrooms, only the teachers possess the kind of expertise that should be passed on to the students. Throughout a student's

educational career, teachers remain in charge of evaluating learning needs and planning and designing learning experiences (Scardamalia & Bereiter, 1994). In the knowledge building process, participants are autonomous agents who identify goals, plan for achieving them, and evaluate their own work. Bereiter and Scardamalia (1989) argued that students should have more control over these features of the learning program. Further, classroom work is often not focused on improving the knowledge of the community but on the completion of activities (Hewitt, 2002; Scardamalia & Bereiter, 1996). Knowledge building is analogous to scientific inquiry that involves students working in a community updating old knowledge and developing new knowledge (Bereiter, Scardamalia, Cassells, & Hewitt, 1997). By simulating the practices of scientific research communities, students can experience question-driven inquiry and explanation-driven understanding in a progressive discourse by working collaboratively (Hakkarainen, 2003). Researchers and educators have attempted to model classroom learning using the scientific inquiry process, with a goal to get students involved in improving the knowledge itself rather than only individual minds. By implementing knowledge building in existing educational systems, students are given more control over their own learning and benefit from the knowledge they created together over the time.

Besides the need for implementing knowledge building into classrooms, there is also a need for a knowledge building society when students graduate from school. The development of expertise is needed to foster the continuous generation of knowledge and pursuit of learning. The pedagogy of knowledge

building helps to build such a society for people's lifelong learning and the advancement of the knowledge base of the society itself. The pervasive aspect of knowledge building demands a knowledge building society for people who have graduated from schools. Also, the computer support from knowledge building makes collaboration possible regardless of time and space limits. The availability of knowledge to the whole society also accelerates the advancement of this knowledge repertoire itself. Out of the school settings, knowledge building continues investing in people and skills to promote a culture of lifelong learning, realizing the potential of information and communication technologies to deliver new learning solutions.

Relation to other CSCL Approaches

As a major theme of CSCL, knowledge building shares many features with other CSCL approaches. In this section I briefly highlight three points: collaboration, use of technology, and learning how to learn (see van Aalst, 2006, for a more extensive discussion).

Collaboration among learners is a very important aspect of most CSCL approaches. For example, in Logo students exchange ideas and collaboratively work on projects within a community of Logo under the support from computers and the internet; in Learning by Design students learn how to make scientific inquiry through collaboration and interaction due to the fact that most of the design challenges are too hard for one person to achieve alone. Knowledge building also depends on collaboration such as occurs in these examples, but it is unique in its emphasis on collective knowledge advancement. The goal is not

just personal learning but to advance the frontier of knowledge in a community, as the community sees it.

Many CSCL approaches use asynchronous discussion environments. However, knowledge building makes unique demands on these environments to support principles such as improvable idea and rise above. That is, knowledge building requires more extensive software features that support working with ideas (e.g., synthesis) after they have been contributed to the discussion.

Like Logo, Learning by Design, and WISE, knowledge building aims to foster *learning how to learn*. However, while Learning by Design and WISE depend on curriculum materials designed by experts, knowledge building does not. In knowledge building, the learning goals and methods for achieving them emerge from the community's discourse.

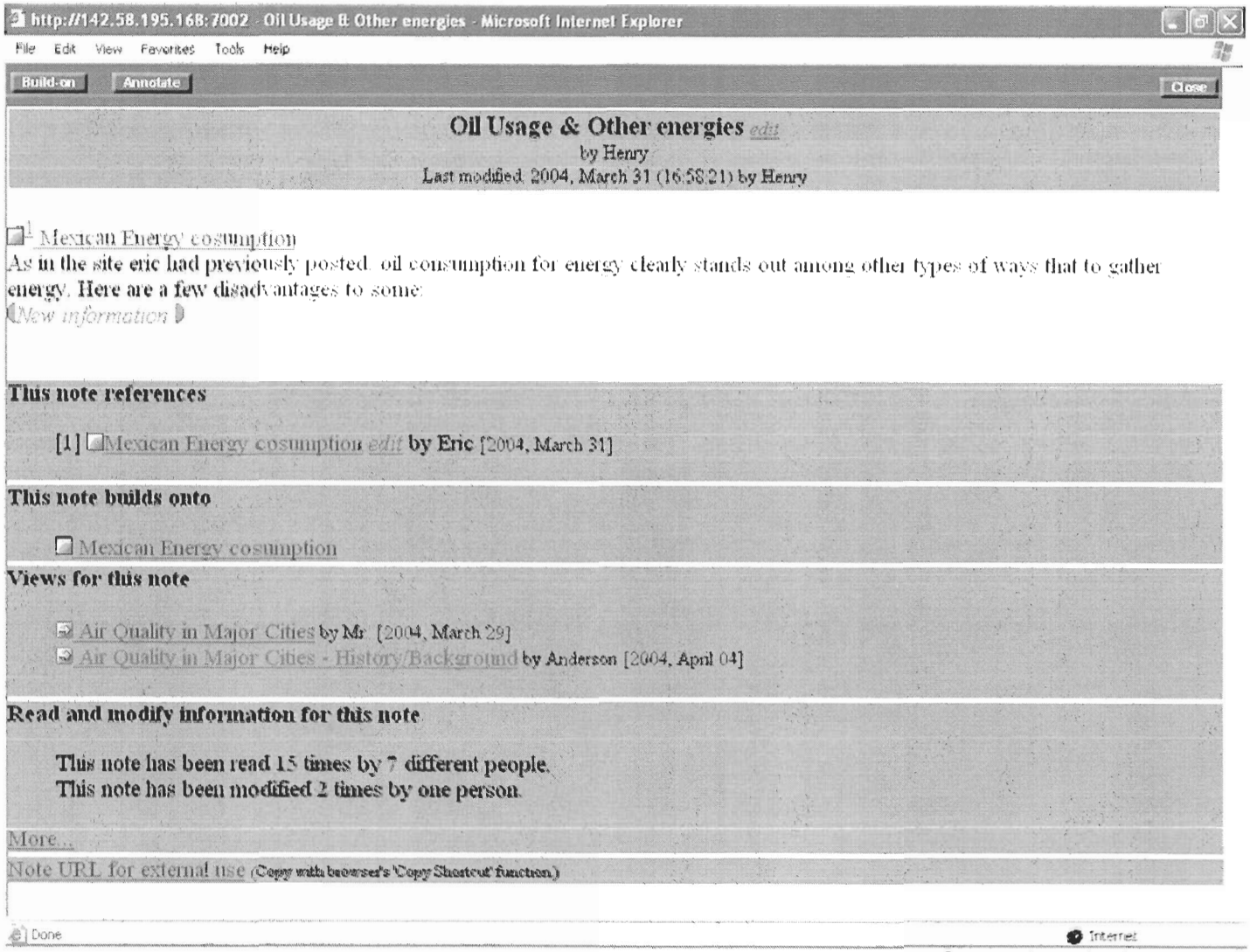
Computer Support for Knowledge Building

Knowledge building usually involves work in an asynchronous discussion environment, which originated as CSILE (Scardamalia et al, 1989). The current version of this software is called Knowledge Forum™ (KF). Knowledge Forum is a networked, computer-based communal database that allows users to create a knowledge building community by sharing information, launching collaborative investigations, and building networks of new ideas together among any number of individuals. The database provides a reliable record of the community members' contributions, which allow them to be revised, referred, linked, developed, and improved. Knowledge Forum is based on more than 15 years of

research, initially focusing on K-12 classrooms. Its use has expanded in recent years to include business, healthcare, and university settings. Knowledge Forum provides a collaborative space, in which ideas can be presented in a network of *notes* and *views*.

Figure 2.1 shows an example of a **note** in Knowledge Forum. A note is the presented form of an individual's idea or information in Knowledge Forum; others can review notes, comment on them, and refer to them in other notes. Students can select text, video, audio, or animation as different presentation modes to communicate in Knowledge Forum. This communication leads to dialogs and an accumulation of knowledge. In a note, text and graphs can be featured the way the author(s) prefer to convey their ideas.

Figure 2.1 Example of Note in Knowledge Forum



Source: Learning in Motion, by permission.

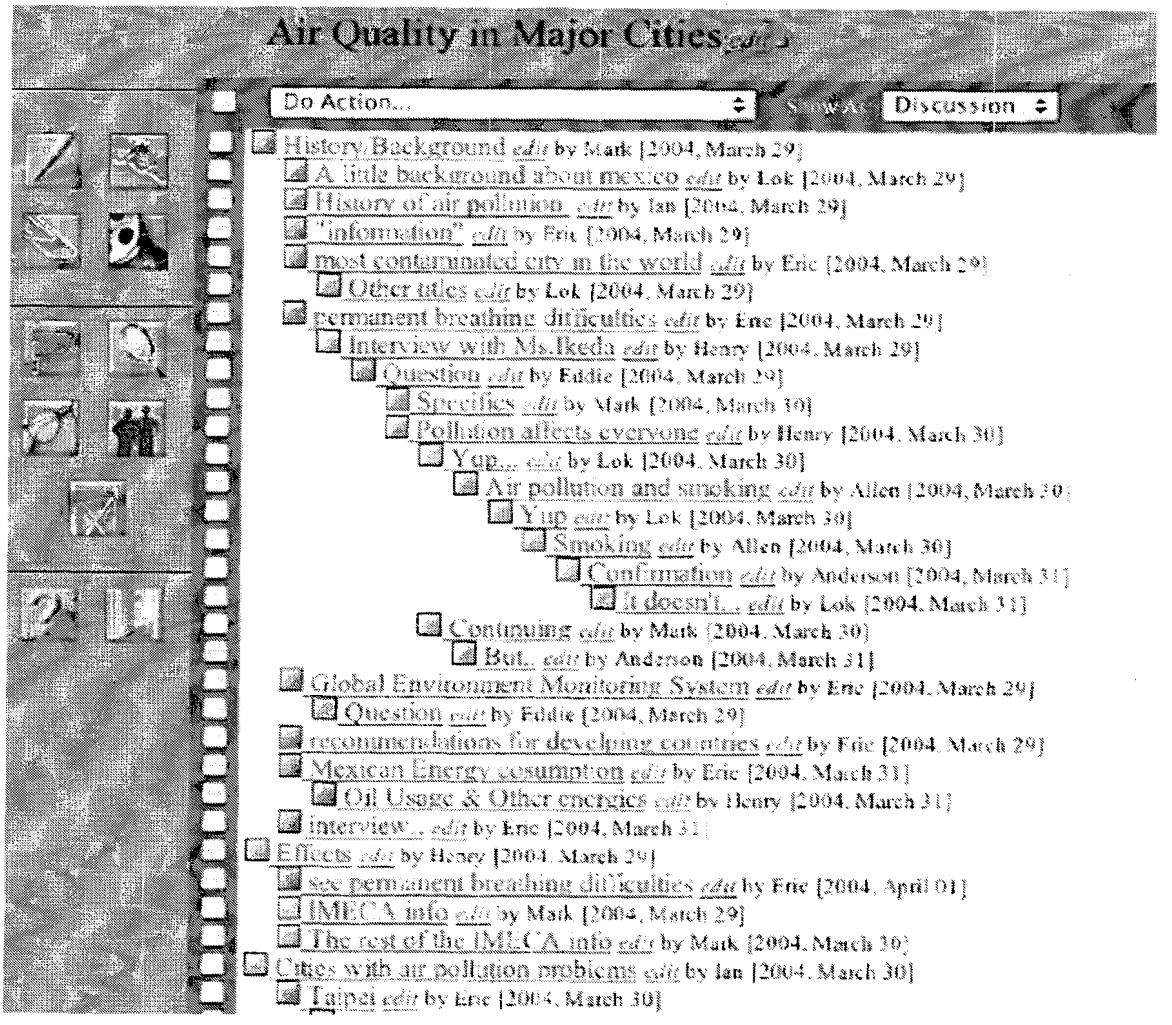
Other notes, to which this note refers and to which it responds, are listed in the note window. Thus, when a reader opens a note, a network of notes, attachments, and views relating to this note are also available to the reader to build a fuller understanding of the discussion. During the note-writing process, one may use built-in, but modifiable, sentence starters such as "I need to understand...," "New theory...," and "My theory..." that help to maintain focus on knowledge building discourse. Such sentence starters are known as **scaffolds** in Knowledge Forum (thinking types in CSILE). A database can be searched for scaffolds. Read and modification information is also available for readers to find out when and how many times a note has been edited, and by who and at what time a note has been read.

Each note is initially placed in a **view**, a window for notes (see Figure 2.2). A view shows an icon for each note in that view, together with information about authorship and the time the note was added to the database. If a note is a response to another note, it is shown indented from the source note. This way, "discussion threads" may become evident. Views can differ greatly on the number of levels in its discussion threads. A preponderance of threads in which there are relatively few levels indicates that although students respond to individual notes, discussions die prematurely. According to Hewitt (2005), many people practice certain online habits, such as focusing attention on the unread notes; this can adversely affect some threads lifespan. The "premature death" of some threads is accelerated by the widespread practice of focusing attention on unread notes during online discussions. The likelihood of inactive thread regain

activity is also reduced when notes are generally neglected after being read. Figure 2.2 shows one thread with 11 levels. The existence of multiple levels in threads provides teachers with a quick impression of the extent to which discussions are sustained.

It is possible to copy note icons to multiple views. So, for example, a note may first be contributed to a view in which the class is exploring a problem, and its icon later added to another view in which the class is discussing what it has learned about a collection of problems. Although only one copy of a note (i.e., the actual information) exists, it is thus possible to create multiple pathways to the note. Links to notes as well as views can also be added to notes, so that one can access a view from within the context of a note.

Figure 2.2 A View in Knowledge Forum



Source: Learning in Motion, by permission.

Studies of Knowledge Building

By the late 1990s, CSILE had become a "beacon technology" in the field of CSCL. Research that enriches and strengthens the theoretical framework of knowledge building covers a variety of disciplines such as business management, health, and education. In education, various studies of collaboration, intentional learning, distribution of expertise, depth of inquiry, conceptual change, and problem solving, have been conducted incorporating the notion of knowledge

building. This section reviews research on knowledge building under the following three categories: (a) knowledge building by elementary school students, (b) by secondary school students, and (c) assessment of knowledge building.

Elementary Schools

Studies in elementary schools have reported that students who used CSILE produced deeper reflections on their own work, and that of their peers, in writing, mathematics, and science (Lamon, Abeygunawardena, Cohen, Lee, & Wasson, 1992; Lamon, Lee, & Scardamalia, 1993). Students also engaged in more student-centered activities, deeper-level cognitive strategies, and better collaboration. In study by Cohen and Scardamalia (1998) with grade five to six students working on computer simulated physics problems, two conditions were compared with different structures embedded in basic science (discourse structure). One condition used face-to-face, small-group interactions, and the other face-to-face and CSILE (Computer Supported Intentional Learning Environments) interactions. The findings showed that in the CSILE supported condition, students engaged in more reflective activity. CSILE supported monitoring and reflection, which resulted in a more even contribution distribution and more productive use of the ideas of collaborators.

Students also appear to be more motivated to engage in learning goals and contributing to the community (Scardamalia et al, 1989). Studies have reported enhancement of depth-of-explanation in knowledge building environments. The classroom culture changed from seeking factual knowledge to producing explanatory knowledge. In research by Lipponen (2000), students who

engaged in explanation-oriented discourse asked explanation-seeking questions instead of fact-seeking ones, demanded clarification and explanation beyond the given information. Students actively used abstract and scientific concepts and the objects of their comments were theories, ideas and methods of research. In a study by Hakkarainen (2003), five levels of explanation were used to measure the content ideas student provided in a CSILE database: separated pieces of facts, partially organised facts, well-organised facts, partial explanation, and explanation. A higher score revealed that the discourse was more explanation-oriented than fact-oriented. Results showed that the explanatory level of knowledge processed across a three-year period became deeper.

Secondary Schools

Studies with secondary school subjects have shown that when engaging in participation in knowledge building processes, students reveal high metacognition (de Jong, Veldhuis-Diermanse, & Lutgens, 2002) and students' engagement in knowledge building is related to conceptual understanding (Chan, Lee, & van Aalst, 2001). In study by Chan, Lam and van Aalst (2003) with grade twelve chemistry courses (knowledge building versus traditional instruction), students from the knowledge building class outperformed the comparison students on conceptual questions and shifted more from the 'transmission' to the 'knowledge construction' views. In a study by Chan Lee and van Aalst (2001) with a grad twelve physical-geography class, students made progress from earlier to later phases such as depth of inquiry, which was shown by the levels of

questions they generated during knowledge building inquiry. Also, students' engagement in knowledge building was related with conceptual understanding.

Studies have also shown that students reveal high metacognition and deeper level cognitive strategies when engaged in knowledge building processes. In a study by Chan and van Aalst (2003) with students from grade nine to eleven, a questionnaire with 27 items reflecting students' view of Agency, Nature of Knowledge, and Social Climate was administered. Results showed differences among classrooms on scores of all three factors. Students' extent of engagement in Knowledge Forum discussions was related to their view on Nature of Knowledge. In a study by Salovaara and Järvelä (2003), students were engaged in only superficial approach towards inquiry at the early stage. However, results also showed a growing amount of collaborative discussion in the CSILE database. Students' engagement in CSILE discussion supports an increase in deeper-level cognitive strategies and progressive inquiries.

Assessment of Knowledge Building

Additional studies have explored *assessment* of knowledge building. A question often asked is "How does one recognize knowledge building?" Chan and van Aalst (2004) argue that assessment of constructivist learning has generally not caught up with modern educational practices. The common problem for innovative practices is that when instruction is drawn from the emerging paradigm, the testing system is held over from the past (Shepard, 2000). Assessment continues to focus on schoolwork and individual performance. Under the assumption that knowledge is a social product, it is required that

assessments can be used to probe both individual and collective aspects of understanding, metacognition, and knowledge construction. In research by van Aalst, Chan, and Lee, knowledge building portfolios have been used as an important assessment tool to evaluate students' metacognition and knowledge building process (Chan & van Aalst, 2003; Lee, Chan, & van Aalst, in press; van Aalst & Chan, 2001).

Despite the importance given in knowledge building to collective knowledge advancement, individual learning is also important. Evidence available thus far suggests that students who use knowledge building are not at a disadvantage relative to conventional assessments. In fact, there is some evidence for improvements over traditional teaching methods in such areas as literacy, mathematics problem solving, reflection on learning, graphical knowledge presentations, and beliefs about learning (Scardamalia, et al, 1992; Scardamalia, et al, 1994). CSILE classes demonstrated greater depth of explanation, greater metacognition, deeper conceptions of learning, and a higher proportion of references to higher-level goals than non-CSILE students (Bereiter & Scardamalia, 1994; Chan, Lam, & van Aalst, 2003). Additionally, Knowledge building activities also benefit learning difficult concepts. In a study by Chan, Burtis, and Bereiter (1997), knowledge building had an important role in conceptual change. Students who employed knowledge building in conjunction with a cognitive conflict approach, outperformed students who had used a direct-assimilation approach on measures of conceptual change. According to Chan *et*

al. (1997), students who used the knowledge building approach recognized the complexity of the situation and the need for deeper investigation of the problem.

Summary

Most of the existing research on knowledge building has focused on elementary school children, measuring conceptual change, metacognition, writing skills, depth of explanation, and standardized tests results (Scardamalia et al, 1989; Cohen & Scardamalia, 1998; Scardamalia, Bereiter & Lamon 1994; Hakkarainen & Järverlä, 2002; Hakkarainen, 2003; Hewitt, 2002; Lipponen, 2000) and post-secondary students (de Jong et al, 2002). Such studies have emphasized how knowledge building is achieved in classrooms, and have left practical objections to making knowledge building central to a class's work relatively unexamined. Little empirical research on high school students using Knowledge Forum has been conducted exploring barriers to implement knowledge building into the curriculum.

Instruments for Analyzing Knowledge Building Discourse

This section introduces two research instruments that are in use in research on knowledge building: the Analytic Toolkit (ATK) and knowledge building principles.

Analytic Toolkit

Burtis (1998) developed a program for retrieving and analyzing server log information called the *Analytic Toolkit (ATK)*; it provides summary statistics on activity in a Knowledge Forum database. The current version (v4.6) provides up

to twenty-seven analyses of how students interact with each other in the Knowledge Forum database, as shown in Figure 2.3.

Figure 2.3 Analytic Toolkit for Knowledge Forum*

- ◯ Database Overview

- ◯ Basic Knowledge Building Measures
- ◯ Use of Features
- ◯ Adding Attachments and Movies
- ◯ Productivity Measures
- ◯ Use of Scaffold Supports

- ◯ Single Author Report

- ◯ Activity (Note Creation/Note Reading)
- ◯ Activity (Note Creation--Details)
- ◯ Activity Log for Single Author

- ◯ Who's Read Whose Notes
- ◯ Who's Coauthored Notes with Whom
- ◯ Who's Built on Whom
- ◯ Who's Referenced Whom
- ◯ Who's Annotated Whose Notes
- ◯ Who's Linked to Whom

- ◯ Group Interaction, Reading
- ◯ Group Interaction, Building on
- ◯ Group Interaction, Linking to Other Work

- ◯ Who Has Read Each Note
- ◯ Note History
- ◯ Growth of Database
- ◯ Word Trace
- ◯ Vocabulary Analyser
- ◯ Custom Report
- ◯ Custom Participation Score
- ◯ Build-on Trees
- ◯ Scaffold Combinations
- ◯ Work Across Views
- ◯ Work Across Views2

*The Analytic Toolkit is a research tool to track activity in Knowledge Forum databases, developed by the Institute for Knowledge Innovation and Technology (IKIT). Printed by permission.

The ATK is designed to be used by teachers and students to examine participation in their own knowledge building discourse. The analyses most often used are "Basic Knowledge Building Measures," "Use of [software] Features," and relational analyses such as "Who Has Read Whose Notes" (see Figure 2.3). The basic knowledge building measures include the number of notes created, the percentage of notes with links to other notes, the percentage of notes in the database that a student has read, and the number of notes revisions.

ATK Indices

In this section the ATK indices that have been used most frequently are described in detail and related to knowledge building concepts.

Notes Created: This productivity measure is the total number of notes created. Building a database minimally requires writing notes; each note represents a thought or information unit. Previous studies suggest that the amount of writing is correlated with depth of explanation (Hakkarainen, Lipponen, & Järvelä, 2002) as well as gains in basic literacy (Scardamalia, Bereiter, & Lamon, 1994). Productive participation through note-writing is a key concern for teachers: If students indeed benefit from writing into a database, students in classes or groups who write more have greater access to such benefits.

Percentage of Notes Read: This is also a general productivity measure: the total number of notes read as a percentage of the total number of notes available for reading. This measure is strongly correlated with Notes Created, and is a strong predictor of depth of explanation, at least for students in elementary school (van Aalst, 1999). Reading other people's notes is the first

step to learning from the community. Technically this measure only indicates the percentage of new notes that are opened. A note opened is not necessarily a note read. However, one cannot read a note without opening it. A low read level would suggest a low level of familiarity with the content of the database, especially if students do not meet face to face regularly to discuss their collaborative inquiry. By contrast, a high read level does not necessarily indicate a high level of familiarity with the content of the database—students could have opened many notes without processing their content deeply. Therefore, this measure should be used together with other knowledge building measures.

Percentage of Notes with Links (to Other Notes): This measure is the percentage of notes that "build on" (respond to), quote, or reference another note. Such linkages among notes produce networks consisting of the individual notes, similar to concepts map or semantic networks. In other words, this measure is not a strict productivity measure but a measure of *how* students make contributions to the database. A high percentage of notes linked indicates that students are attempting to relate their ideas to ideas already represented in the database. This process is essential to improving the community's ideas. Links provide multiple pathways to ideas.

Note Revision: Another activity that is specific to knowledge building is the revision of notes; an important notion in knowledge building is that ideas are seen as improvable objects (Bereiter, 2002). If students treat ideas as improvable, one way it may be evident in a database is through a high number of note revisions. However, some students could simply be saving a note frequently from

fear of losing the note during a technical problem, without a commitment to idea improvement. A high number of note revisions can be checked against the Note History analysis in the ATK to ensure that note revisions are separated temporally (i.e., that they do not occur within the same session). By contrast, an obvious lack of note revisions could indicate a low level of idea improvement, although this should be checked by examining other ways students could be improving ideas in Knowledge Forum (e.g., writing new notes that are linked to earlier ones).

Scaffold Use: Scaffold use is an effort to make the database more useful as a knowledge building resource, because scaffolds can be used to search the database and assist the members in maintaining focus on theory building. Scaffolds are metacognitive prompts that guide knowledge construction (Chan & van Aalst, 2003; Lee, Chan, & van Aalst, in press). In an exploratory study, van Aalst and Chan (2001) found that the use of scaffolds had a medium correlation with portfolio evaluations.

Using the ATK Indices

Little work has been done to validate ATK indices as measures of knowledge building, but some studies exist that can be used to determine how descriptive statistics compare with those obtained in other contexts. van Aalst, Teplovs, Burtis, and Scardamalia (1999) used descriptive statistics obtained from the ATK to examine how an individual or a group uses Knowledge Forum and to assess whether students were reading, writing, revising, and collaborating. The ATK has also been used to investigate whether there are improvements of

student engagement over time (Chan, Lee & van Aalst, 2001; van Aalst & Chan, 2001), and how ATK indices are related to other knowledge building measures and conceptual understanding (Chan, Lee, & van Aalst, 2001; Lee, Chan, & van Aalst, in press). Analyses indicated that several ATK indices (Scaffold Use, Percentage of Notes Read, and Note Revision) had moderate to high correlations with knowledge building portfolio ratings. Note Revision was shown to be correlated with conceptual understanding. These findings suggest that scaffolds and revision are key aspects of knowledge building, because it is important that students use metacognitive prompts to direct their knowledge construction and continually revise their ideas. In addition, literature using other asynchronous discussion environments can assist interpretation of ATK indices. Specifically, Guzdial and Turns (2000) analyzed sustained on-topic discussions in computer-mediated discussion forums, such as CaMILE. They used participation ratio, note per author, and thread length to analyze the effectiveness of a discussion. Hsi (1997) found that grade eight students wrote on average 4.82 notes over an 18-week period in research with the Multimedia Forum Kiosk. Existing studies have used the individual student as the unit of analysis, but interest in using larger units of analysis such as a group engaged in collaboration has been growing (van Aalst, Kamimuara, & Chan, 2005).

Knowledge Building Principles

In Chapter 1, I summarized the vignette using six informal features of knowledge building. Here, I provide a more formal lens for examining knowledge building. A reasonably comprehensive list of qualitative features of knowledge

building could be used to examine if the online discourse is a knowledge building discourse or a different kind of discourse. For example, from the ATK we may learn that students frequently comment on each other's ideas, but we do not learn whether such comments are aimed at idea improvement. Nor do we learn that way if students are dealing with what I referred to as "complex problems that in general do not have agreed-upon solutions" or if they are working toward collective knowledge advancements.

To provide a formal lens for analyzing knowledge building, Scardamalia (2002) proposed a system of twelve knowledge building principles. They are based on literature on knowledge building, reviewed earlier in this chapter, and classroom examples of knowledge building which have accumulated over 15 years. They have been used as guidelines for designing classroom environments (Reeve, 2001) and for evaluating evidence for knowledge building (Law & Wong, 2003). I first state the principles and then provide a more detailed description for the principles that are most relevant to this thesis.

The principles are: (1) real ideas, authentic problems, (2) improvable ideas, (3) idea diversity, (4) rise above, (5) epistemic agency, (6) community knowledge, collective responsibility, (7) democratizing knowledge, (8) symmetric knowledge advancement, (9) pervasive knowledge building, (10) constructive use of authoritative sources, (11) knowledge building discourse, (12) embedded and transformative assessment. The reader may verify the approximate correspondence between the six items in the list in Chapter 1 and these principles. For example, Scardamalia refers to "complex problems that in general

do not have agreed-upon solutions" as *real ideas, authentic problems*, and to "Students study previous work on a problem but use what they learn this way to build knowledge that is new to the class" as *constructive use of authoritative sources*.

Epistemic Agency

Participants take charge of their own learning; rather than being controlled by the teacher, they exhibit a high level of awareness of responsibility for personal understanding and for the creation of new knowledge for the community. They coordinate their own ideas with those of others, identify the gap between personal ideas and public understanding, make effort to bridge this gap by negotiating with community ideas, and plan and monitor their collaboration process. Developing epistemic agency involves taking responsibility for learning elements such as goals, motivation and evaluation of understanding, which are often directed by teachers in traditional classrooms.

Real Ideas, Authentic Problems

During the process of knowledge building, problems are raised by participants themselves in the context of their interests, problems that are currently important to their world, as oppose to being ready-made problems that are provided by the teacher. Learners raise these questions because they care about them as part of their real lives instead of being told what to learn. The problems that students investigate emerge naturally in the context of the existing curriculum. The teacher could encourage behaviours relating to this principle by designing more open-ended assignments and explaining to students that real

ideas are valued. For example, a group of students are working under the topic of "waste management", the requirement was to identify the problem on a map and develop solutions to this problem. The students' first attempt was to narrow down the topic to a specific area or a specific type of waste because the topic is generally agreed in the group to be very broad. After some discussion, they decided to focus on household waste. The idea of investigating in household waste was raised by participants according to the problem that is important to their world—being able to focus so that it is possible to perform on the task.

Idea Diversity

The principle of idea diversity states that it is useful to have multiple students contribute ideas to a discussion; this may make the students think more dialectically. Students are encouraged to bring up different prospects of a problem and examine them critically. Different ideas create a rich dynamic environment where contrasts, competition, and complementarity of ideas is possible and evident. Idea diversity is essential to the process by which ideas evolve in a knowledge building community by providing more choices for inquiry.

Improvable Ideas

All ideas are treated as improvable. No statements are final in knowledge building; there is always space to improve. Ideas are accepted or rejected according to their logical argument and evidence. Participants work continuously on the improvement of the quality, coherence, and utility of ideas, gathering and evaluating evidence, and ensuring that explanations consist with all available evidence. For such work to prosper, the culture must be one of psychological

safety, so that people feel safe in taking risks—revealing ignorance, voicing half-baked notions, giving and receiving criticism.

Rise Above

It is easier for most people to deal with the concrete, immediate, and simple than to cope with complexity, diversity, and messiness. Knowledge building entails working toward higher-level formulations of problems through learning to work with diversity, complexity and messiness. By moving to higher levels of understanding, knowledge builders achieve new syntheses and move past the current best practice. Knowledge building communities establish the context for moving to increasingly higher levels for solving problems by creating shared visions to guide them, and by developing systems that accommodate emergent goals.

Rubric for the Knowledge Building Principles

Law and Wong (2003) developed a rubric based on ten of the knowledge building principles as a measure of knowledge building. They conducted research on 250 students in five secondary schools in Hong Kong. The focus of their study was to evaluate the extent to which the characteristics represented by the knowledge building principles could be observed in the discussions in the Knowledge Forum environment. The evaluation was conducted on a group basis rather than for individual students. Each group's discussion was evaluated as-a-whole and given a score on a scale of 0 (lowest) to 3 (highest) for each principle based on the extent to which the discussion quality met the respective criteria used for each principle. The results suggested there is a hierarchy of accessibility

among the principles, and Law and Wong identified interrelationships among the principles. Some of the knowledge building principles such as collaborative cognitive responsibility and democratizing knowledge had high scores, while principles such as constructive use of authoritative sources and embedded and transformative assessment had lower scores. There was also a tendency for the presence of some of the knowledge building principles to appear together, which indicated a possibility for some principles to be more closely linked, such as collective cognitive responsibility and democratizing knowledge.

Summary

This chapter framed the study against literature on CSCL, described knowledge building and Knowledge Forum in more detail than was provided in Chapter 1, and introduced two empirical tools for investigating knowledge building discourse: the Analytic Toolkit as the tool for analyzing server log data and knowledge building principles for analyzing the quality of collaborative discourse.

The next two chapters report empirical studies of participation in knowledge building—using the ATK and knowledge building principles—based on two implementations by the same teacher. The first study, presented in Chapter 3, is *retrospective* because it is based on an already competed Knowledge Forum database. The second study, presented in Chapter 4, is not retrospective; this made it possible to measure several variables hypothesized to influence participation in knowledge building.

CHAPTER 3: IMPLEMENTATION 1

This chapter presents an analysis of participation in online knowledge building discourse. As explained in previous chapters, teachers may accept knowledge building for some students, or offer it as an extra-curricular option, but raise concerns about its suitability for classes with substantial variability in achievement (van Aalst & Hill, 2001). Such perceptions are problematic for the widespread implementation of knowledge building. For example, advocates of *learning how to learn*, one expected benefit of knowledge building, argue that students of all academic levels need it and can achieve it (EMB, 2000; van Aalst, 2006; White & Fredericksen, 1998).

An opportunity to examine participation in knowledge building arose when a teacher new to knowledge building implemented it in two concurrent versions of a tenth grade social studies course—one mainstream, the other honours. Students used Knowledge Forum during a three-week collaborative inquiry on environmental issues; each class developed its own database. The teacher chose to begin his exploration of knowledge building with environmental problems because this area offers open-ended problems without generally accepted solutions and it had high student interest. The two classes worked through essentially the same instructional design to investigate current problems relating to the environment, such as deforestation. To study participation in online knowledge building discourse in the two databases, the Analytic Toolkit (ATK)

was used to retrieve and analyze server log data; the qualitative features of a sample of the discussions were then analyzed using the knowledge building principles described in Chapter 2.

It was hypothesized that although one would expect to observe significant differences in quantitative measures of participation between the two classes obtained from the ATK, deeper analysis could reveal online behaviours in both classes conducive to knowledge building, as well as online behaviours that inhibit it. From the perspective of knowledge building, the qualitative features of the discourses as measured by the knowledge building principles, could also be similar between the two classes. The study had three research questions. The first two of these examined how students in mainstream and honours social studies courses participated in online discussions; the third asked whether these online discussions could be considered instances of knowledge building. Specifically, the research questions were

1. To what extent do students in mainstream and honours social studies courses participate in online knowledge building discussions?
2. How does participation in knowledge building discourse vary across groups of students who are collaborating, disregarding the level of the course in which the students in a group are enrolled?
3. Do the online discussions in both courses resemble knowledge-building discourse?

(The fourth research question stated in Chapter 1 was studied in the second implementation).

Method

The research problem required a study of participation in online discussions, as these occurred in the context of an actual instructional program. The nature of the problem under investigation—concern about variability among students' participation—required analysis of variance of individual measures of participation. Thus, neither a qualitative study such as a case study nor a true experiment (with random assignment of participants to the experimental conditions) was appropriate. The study examined participation in online discussions during a teacher's first endeavour with Knowledge Forum, and examined only the productions (i.e. the Knowledge Forum database) generated by students in the context of the instructional program. No instruments could be administered to measure potential moderating variables (before or after instruction). A study of this type is retrospective; Abrami, Cholmsky, and Gordon (2001) refer to the research design as a *static group comparison design* (p. 37).

Using the individual student as the unit of analysis in a study of collaboration is problematic, although the problem has been neglected in educational research for many years. Stevens (2002) has stated:

> [In] cooperative learning ... students work in small groups, interacting with each other and helping each other learn the lessons. ... Many studies have compared cooperative learning versus individualistic learning. A review of such studies in the "best" journals since 1980 found that about 80% of the analyses were

> done incorrectly (Hykle, Stevens, & Markle, 1993). That is, the investigators used the subject [participant] as the unit of analysis, when the very nature of cooperative learning implies dependence of the subjects' scores within each group (p. 258).

According to Stevens, even a minor violation of the independence assumption produces a dramatic increase in the Type I error rate (the probability of concluding that an effect is statistically significant when it is not). He recommends using group averages as the unit of analysis or setting the alpha level (the Type I error rate, the significance level) more stringently.

After preliminary analysis, I calculated intraclass correlation coefficients and estimated their effects on the Type I error rate to determine how to adjust the alpha level (see Stevens, 2002, p. 259). If a comparison between two groups has a high intraclass correlation, one may infer the general behaviour of the entire class from that of a few students in the class. It turned out that the intraclass correlations were in the range .20 to .40 for most Analytic Toolkit (ATK) indices. In this study, as an example, this would lead to Type I error rates of approximately .50 to .70.

One could set the alpha level at .005 instead of .05; this would make the observed Type I error rate in the range .05 to .07. However, it would introduce two new problems: reduced statistical power and an increased Type II error rate (the probability of *failing* to detect a statistical difference when one does exist). In this study, it was crucial to maintain an acceptable Type II error rate: with too high a Type II error rate, it would be impossible to acknowledge that a real difference between the classes (i.e., one that is not due to chance) exists. Thus,

there must be a compromise between maintaining a low Type I error rate and a low Type II error rate. Therefore, **in all statistical tests, the alpha level was set at .01**. This means that the *actual Type I error rates* are in the range .10 to .14. I calculated the actual power and Type II error rate for one comparison (a between-class difference of .5 standard deviation for Scaffold Use), and obtained .83 and .17. Although future research needs to develop measurements with lower Type I error rates, I believe these numbers are acceptable for an exploratory study.

The Teacher

When commencing this study, the teacher had nine years of experience teaching elementary school to grade twelve students. As well, he had a Master's degree focusing on instructional strategies. In the classroom, the teacher conducted learner-centred approaches, using goal-driven planning, stressing active learning and interactivity, and giving frequent support and feedback. He had incorporated some aspects of active learning and cooperative learning in his teaching before this study.

The unit under study here was the teacher's first work with Knowledge Forum and knowledge building. In an interview conducted upon conclusion of the unit under investigation, he gave the following reasons why he was interested in this research: "... knowledge building can have kids looking at how they are gaining knowledge and research skills, and what they can do to process the information to deepen understanding." The teacher also suggested that an online

environment may give students more equitable participation opportunities for group learning. (For example, students who do not speak up frequently in class discussions could contribute more frequently to online discussions.) Additionally in such environments, lower achieving students could see how higher achieving students organize their thinking and present their ideas.

The teacher had taught the content of this unit for three years before this study; he enjoyed facilitating knowledge building, helping students to direct, or challenge their thinking, instead of lecturing. However, after this unit and upon speaking with other teachers who were using Knowledge Forum at this school, he became concerned that the knowledge building approach would only suit the honours students (interview, July 15, 2004).

Participants

The school was located in a suburban area in the Canadian province of British Columbia. According to statistics released by the British Columbia Ministry of Education (2005), the school had typical demographics for the province, except that the proportion of students from homes where English was not the first language was high (48%, compared with 20% for the province), and the educational level of adults in the community was higher (81% graduated from high school, compared to 68% for the province). It was a relatively new school with more than 1500 students. At the time of this study, the school and the community in which it was located were ethnically diverse. More than 300 students were enrolled in the English as a Second Language (ESL) program; fifty

percent of the student population were born outside of Canada. Major ethnic groups within the school included Persian, Chinese, Korean, and Canadian. The majority of students in the school were well motivated academically, and many were expected by their families to attend university following graduation. Parents of the students had high aspirations for their children and were supportive of the school's programs.

The participants were students from two classes—one mainstream, one honours—taking grade ten social studies from the same teacher. There were twenty-eight students (thirteen males and fifteen females) in the mainstream class and thirty (fifteen males and fifteen females) in the honours class. All students were new to knowledge building.

Curriculum and Procedures

According to the British Columbia (BC) Ministry of Education website (http://www.bced.gov.bc.ca/irp/ss810/ass10.htm), this grade ten social studies course consisted of five interrelated curriculum organizers that reflected the multidisciplinary nature of this subject: applications of social studies, society and culture, politics and law, economy and technology, and environment. In the "environment" component, students were expected to learn geographical skills and apply them to enhance their understanding of natural environments. They were expected to apply these skills to understand relationships between people and natural systems, to explore the influence of physical geography, and to study

physiographic regions. Students were then expected to apply their understanding to areas such as resource development, stewardship, and sustainability.

The instructional unit in which knowledge building was implemented focused on environmental studies. The teacher provided a set of "authentic" problems, which he described as "real to the students' everyday lives; none of the environmental problems had a generally accepted viable solution." Students in each class collaborated in groups of approximately eight to investigate one of these problems. They identified and studied relevant background documents, including the textbook and online resources such as government websites, discussed these, and made recommendations for what they thought should be done about the problems. The collaborative work was designed to proceed in several phases: (a) showing the area of concern on a world map; (b) identifying the problem with historical and current information; (c) identifying causes, consequences, and solutions to the problem; (d) and explaining difficulties one might face in implementing a proposed solution. This design was similar to structure the teacher had provided to students in previous implementations of the unit (as individual projects). The final product of each group consisted of an a recommendation informed by the group's research. At the end of the unit, students individually prepared a portfolio of their learning. The unit lasted three weeks.

The teacher started two Knowledge Forum databases to support these inquiries—one for each class. To limit the number of notes individual students would encounter, each group had its own area in the database for its class,

consisting of a view for each of the above-mentioned stages of the inquiry. Students joined a group based on interest in a specific environmental problem, with the condition that all groups should have seven to eight students. The group composition and topics (i.e., environmental problem) are shown in Table 3.1. Groups A to D were in the mainstream class and Groups E to H in the honours class.

Table 3.1 Grouping Features

Mainstream [a]			Honours		
Group	Students	Topic	Group	Students	Topic
A	6 male, 2 female	Pine beetles	E	8male, 0 female	Air quality in major cities
B	5male, 1 female	Sydney tar ponds	F	5 male, 3 female	Chernobyl
C	5male, 2 female	Chernobyl	G	0 male, 7 female	Arctic biome
D	0 male, 6 female	Britannia Mines Disaster	H	2male, 5 female	Rainforest destruction

[a] The mainstream class had one student who did not participate in the group discussion; he was excluded from the grouping and did an independent project.

The teacher introduced Knowledge Forum to students in class and demonstrated features of Knowledge Forum using a projector. An unintended difference in procedures between the two classes was that the honours group practiced using Knowledge Forum prior to beginning their inquiries on environmental studies, whereas the mainstream class did not. The honours class discussed topics provided by the teacher; these topics were relevant to the course but did not pertain to the unit on environmental problems. The views for practice were "Canadian identity - an introductory topic," with 246 notes, "rights of women," with 53 notes, and "responsible government," with 92 notes. Because the teacher was not aware of the importance of providing equal intervention to

the mainstream and honours class, he provided the opportunity for practice only for the honours class to get students familiar with Knowledge Forum.

Students used Knowledge Forum primarily in the school computer lab and at home during the three-week unit. For class use of Knowledge Forum, the computer lab was booked ahead of time and students would spend the whole class time in the lab. Students could also contribute from home computers after school. According to the statistics provided by Human Resources and Skills Development Canada (HRSDC) in May 2004, "87.9% of fifteen-year-old Canadian students have at least one computer available to them at home." As to the provincial differences, "Students from Ontario and British Columbia reported the highest incidence of access to a computer at home (93% for both provinces)" (HRSDC, 2004, ¶2). Thus, computer access for the students was not likely to be a problem.

How students are assessed can critically influence how they participate in online discussions. For example, if students are expected to write three notes per week they may write to meet this requirement, but the notes may not have much value to the ongoing discussion. In this unit, students were not evaluated on the basis of their ongoing contributing notes to Knowledge Forum; rather, each student prepared a brief portfolio demonstrating his or her learning at the end of the unit. Perhaps as a result of this evaluation procedure, the teacher did not systematically analyze the discussions or comment on them in Knowledge Forum, although he regularly read and notes when students had them open during class and asked students if they were making progress or needed assistance.

However, when students began preparing their portfolios, the teacher related the topics of investigation to the prescribed learning outcomes provided by the Ministry of Education to provide synthesis across the work by different groups.

In the teacher's view, the unit fit well with the prescribed curriculum for grade ten social studies. During an interview he commented

> In terms of content, the unit certainly was in the geography as physical geography requirements in the IRP [Integrated Resource Package, the curriculum guide from the Ministry of Education] in grade ten...It's more focused on the western Canada. And in terms of research skills, integrating technology, working together with peers and then interacting with the computer, with the library, and with the classrooms, it is certainly a large part of the IRP in grade ten... (interview, July 15, 2004).

From a researcher's perspective, this unit offered an opportunity to explore classroom implementation of knowledge building. There appeared to be good potential for observing some knowledge building principles during the online discussions, such as democratising knowledge and idea diversity (see Chapter 2); according to prior research, these principles are easier to access than other knowledge building principles such as epistemic agency (Law & Wong, 2003). At the same time, some knowledge building principles would appear to be underrepresented, such as constructive use of authoritative sources and rise above. The problems of inquiry, although not fully specified, were provided by the teacher, and this could undermine the goal to make students agents of their own learning (cf., epistemic agency).

The short duration of the unit (three weeks) would also raise questions about features of knowledge building that are emergent, such as rise above.

Overall, given the constraints of the curriculum, the instructional design appeared to be a reasonable one with which a teacher could begin exploring knowledge building in the classroom. However, we should expect the evidence in support of knowledge building to be limited.

Data and Measures

Statistical data describing student behaviour in Knowledge Forum were analyzed. To evaluate the *quality* of the interactions, I divided the topics into "discussions" (groups of notes that seem like separate discussions), and rated these using Law and Wong's (2003) rubric based on the knowledge building principles (Scardamalia, 2002; see Appendix B). Previous research (Chan, van Aalst, & Lee, 2002) has shown that it is difficult to identify different aspects of knowledge building within single notes or within the work of individual students. Knowledge building takes place over a period of time and involves multiple participants. For example, epistemic agency is a process of negotiating one's own ideas with the public beliefs (Scardamalia, 2002). One single note can demonstrate only a step of this process. To reveal epistemic agency, single notes or individual work are not sufficient. Instead, it is necessary to examine a series of notes to demonstrate the process of the negotiation of idea fit. Thus, I selected discussions and examined the evidence that each discussion provided for knowledge building.

Analytic Toolkit (ATK) Indices

The following ATK indices were retrieved: Notes Created; Percentage of Notes Read; Percentage of Notes with Links to Other Notes; Scaffold Use, and Note Revision. As I explained in Chapter 2, the first two of these are productivity measures, while the last three are more specific to how students work in Knowledge Forum in relation to knowledge building concepts. The notes written by the honours class in its practice views were excluded from the analysis because the mainstream class did not have such views.

Knowledge Building Principles

Scardamalia's (2002) knowledge building principles and the rubric by Law and Wong (2003) were used to assess the qualitative features of a sample of the discussions by each class. Within each class, I calculated *z* scores for all the ATK indices and an average *z* score; all the views by the group with the smallest *z* score (in absolute value) were then selected for the analysis. In other words, the group selected for the analysis from each class was the group with the most average and most probable participation levels, as measured by the ATK indices. For the mainstream class, the topic "Chernobyl" was selected and for the honours class "Rain Forest Destruction." To test whether a reasonable amount of information was available for both topics, I conducted Google searches within Canadian web sites using the topics as keywords. For both topics a large number of documents were retrieved: 95,700 for "Chernobyl" and 119,000 for "rain forest destruction." Reading the first page of documents in the output, I satisfied myself

that students had reasonable access to documents at a reading level accessible to grade ten students for both topics.

Some alternations were made to Law and Wong's (2003) rubric for this study. For example, Because the teacher did not suggest "rise above" behaviour in this unit, all the discussions scored zero for this principle upon preliminary analysis. Therefore, the principle of "rise above" was excluded from the analysis, and I used a subset of the coding scheme from Law and Wong (2003). In total, nine principles were used to analyze the sociocognitive aspects of the discussion in Knowledge Forum (see Appendix B, together with their evaluation criteria).

Chi (1997) suggested several segmenting techniques to evaluate qualitative data, including non-content features like syntax and semantic features. In this study, I applied segmentation based on the semantic features of the verbal data because this is "psychologically more meaningful" than using other features (Chi, 1997, p18).

I used a "discussion" as the unit of analysis to segment the views selected for the analysis. A discussion is not necessarily a view, or a thread, but a complete developmental process of an idea, or several interrelated ideas, that concern the same topic or subtopic. An example is a complete line of thought with questions and explanations, whether or not they lead to consensus. An example of a knowledge building principle could occur within a note or across several notes, and a given discussion could have more than one example of a principle.

The rubric by Law and Wong (2003) was used for coding the discussions. This rubric identifies several features for each principle. A score between 0 and 3 was assigned depending on how many features were present. A higher score was assigned if the discussion provided evidence for a greater number of the features of a principle. For example, for "epistemic agency" the features are *theory construction* (the group shared the responsibility for the advancement of knowledge) and *theory refinement* (members compare and contrast the ideas contributed by each other). A discussion receiving a score of "3" for epistemic agency would provide strong evidence for both theory construction and theory refinement; a discussion receiving a score of "2" would have strong evidence for only one feature and weak evidence for the other or moderate evidence for both; and a score of "1" would result from weak to moderate evidence for both features. I coded each example of a principle in the discussion and used the highest score.

There were three discussions for the mainstream class and nine for the honours class; the total number of instances of the principles in these discussions was 23 for the mainstream class and 36 for the honours class (recall that there might be evidence for a principle in more than one place in a discussion). 50% of these were rated by an independent rater; the inter-rater reliability was 80% (Pearson correlation coefficient). Appendix B provides examples of the application of the rubric.

Results

The mainstream class wrote 327 notes and the honours class 623. Of the 52 discussion threads created by the mainstream class, 43 (83%) had less than 6 notes; this percentage was smaller for the honours class (56%). These general features of the databases are consistent with the teacher's impressions about participation levels. The results are reported in three subsections—one for each research question.

Between-Class Comparison of ATK Indices

The first research question was: "To what extent do students in mainstream and honours social studies courses participate in online knowledge building discussions?" This question was addressed by a between-class comparison of ATK indices. Table 3.2 shows the ATK indices for individual students in the two classes. The honours class had larger means for Notes Created and Percentage of Notes with Links to Other Notes. However, the standard deviations for Percentage of Notes with Links to Other Notes were larger for the mainstream class than the honours class. Individual students in the mainstream class, on average, wrote 11.7 notes, or almost four notes per week; approximately one in two notes was linked to at least one other note. The percentage of notes read seemed low, as did Scaffold Use and Note Revision. For example, both classes used scaffolds infrequently compared to the number of notes written: on average, students in the mainstream class used

approximately one scaffold in 2 notes. The honours class used scaffolds less frequently than the mainstream class—one in 3 notes.

Table 3.2 Basic Knowledge Building Indicators per Student for Mainstream Class and Honours Class

	Mainstream		Honours	
	Mean	SD	Mean	SD
Notes Created	11.7	11.1	20.8	10.1
% Notes Read	17.5	19.2	21.0	10.8
% Notes with Links	41.9	34.2	82.8	16.2
Note Revision	4.0	5.5	4.0	3.5
Scaffold Use	5.8	10.2	3.2	3.5

A multivariate analysis of variance (MANOVA) showed that the five ATK indices significantly differentiated the two classes, F (5, 52) = 14.13, $p < .001$, Wilks' $\Lambda = .42$, $\eta^2 = .58$. Accompanying this overall effect was a significant univariate effect for Percentage of Notes with Links: 41.9% for the mainstream class, compared with 82.8% for the honours class, F (1, 56) = 34.40, $p<.001$, $\eta^2=.38$. The difference for Notes Created was not significant at the .01 level, F (1, 56) = 10.48, $p<.05$, $\eta^2=.16$.

Between-Group Comparison of ATK Indices

The second research question was: "How does participation in knowledge building discourse vary across groups of students who are collaborating, disregarding the level of the course in which the students in a group are enrolled?" This question was addressed by a between-group comparison of the ATK indices. Table 3.3 corresponds to Table 3.2, and shows the group means

and standard deviations for the five ATK indices. Groups A to D were in the mainstream class and Group E to H in the honours class. The groups highlighted in the table were used for verbal analysis. Groups and data in bold letters were selected for verbal analysis.

Table 3.3 Mean (SD) ATK Indices for Groups A-H

Group	Notes Created	% Notes Read	% Notes with Links	Note Revision	Scaffold Use
A	23.6 (14.5)	36.8 (23.1)	68.8 (15.4)	3.9 (2.4)	16.0 (15.0)
B	8.2 (4.7)	14.8 (17.1)	23.2 (23.4)	8.8(10.2)	2.0 (2.3)
C	**7.6 (3.6)**	**10.4 (5.4)**	**59.6 (28.6)**	**3.0 (2.2)**	**1.0 (0.6)**
D	5.8 (1.8)	5.0 (2.8)	11.2 (12.6)	1.0 (0.9)	2.7 (2.7)
E	47.0 (17.0)	40.1 (14.3)	97.0 (3.2)	6.3 (2.2)	5.9 (4.4)
F	24.6 (7.2)	15.4 (6.8)	86.3 (11.1)	4.4 (3.5)	1.0 (1.6)
G	26.4 (7.6)	25.4 (12.8)	81.0 (10.9)	5.9 (5.6)	1.9 (2.3)
H	**35.6 (13.3)**	**20.6 (3.0)**	**90.7 (6.2)**	**4.0 (3.3)**	**3.9 (2.9)**

Note. Groups A to D were in the mainstream class and groups E to H the honours class. Groups and data in bold letters were selected for verbal analysis.

Groups from the honours class generally had larger means than groups from the mainstream class for variables such as Notes Created, Percentage of Notes with Links to Other Notes. However, Group A from the mainstream class had means that were larger than some groups' from the honours class. For example, for Percentage of Notes Read was larger for Group A than for Group F, G and H. Additionally, group differences occurred not only between classes but also *within* class. For example for Notes Created, Group E not only outperformed groups A-D from the mainstream class, but also other groups from the honours class.

A MANOVA showed that the five ATK indices significantly differentiated the eight groups: F (7, 49) = 5.4, p < .001, Wilks' Λ = .06, η^2=.44. The following univariate effects were statistically significant: Notes Created, F (7, 49) = 8.8, p<.001, η^2=.56; Percentage of Notes Read, F (7, 49) = 9.00, p<.001, η^2=.56; Percentage of Notes with Links, F (7, 49) = 14.56, p<.001, η^2=.68; and Scaffold Use, F (1, 56) = 5.2, p<.001, η^2=.43. The effect sizes (η^2) for this analysis were substantially larger than for the between-class comparison, suggesting that between-group differences in participation are important to consider.

Verbal Analysis of Discussions Using Knowledge Building Principles

The third research question was: "Do the online discussions in both courses resemble knowledge-building discourse?" To investigate this question, a sample of views was coded with Law and Wong's (2003) rubric based on Scardamalia's (2002) knowledge building principles. The topics were selected as described in the method section with views that had no less than six notes. The views were divided into discussions, using Chi's (1997) segmentation technique, and rated with Law and Wong's (2003) rubric. For the mainstream class, the topic was divided into three discussions (53 notes) and for the honours class nine (140 notes). This includes all the notes in the views selected for the analysis. The results are presented in Table 3.4. In the table, I also report the rank of each principle; Law and Wong referred to this rank as the "accessibility" of the principle.

Table 3.4 Discussion Quality Scores

Knowledge building Principles	Chernobyl Mainstream (n=3)		Rainforest Honours (n=9)		Rank
	Mean	SD	Mean	SD	
Democratizing knowledge	2.33	.58	2.56	.73	1
Idea diversity	2.67	.58	2.44	.53	2
Community knowledge	2.33	.58	2.44	.88	3
Improvable ideas	2.00	1.00	2.00	.70	4
Epistemic agency	2.00	1.00	1.67	.50	5
Knowledge building discourse	1.33	.58	1.78	.67	6
Constructive uses of authoritative sources	1.33	.58	.78	.67	7
Real ideas	1.33	.58	.33	.50	8
Embedded and transformative assessment	1.00	1.00	.33	.50	9
Total score [a]	16.32	6.48	14.33	5.68	–

[a] Total score is the sum of all the scores from each principle.

Results were similar for both classes. Mean scores were relatively high for some principles. For *idea diversity*, *democratizing knowledge*, and *community knowledge*, they ranged from 2.33 (78 % of the maximum possible score) to 2.67 (89%). This finding suggests that in this respect both classes were engaged in knowledge building. Evidence was weakest for *real ideas*, *constructive use of authoritative sources*, and *embedded and transformative assessment*, with scores ranging from .33 (11 %) to 1.33 (44 %), consistent with Law and Wong's (2003) results. This finding suggests that the online discussions also fell qualitatively short of knowledge building. For example, there were many notes, often linked to other notes, the honours class received low scores for constructive use of authoritative sources.

Summary

This chapter reported an exploratory study of participation in knowledge building using server log data obtained from the ATK and ratings of discussions. Before reporting on the second implementation, the findings are summarized.

The findings from the between-class comparison of the ATK indices were promising. For example, in three weeks, students in the mainstream class on average wrote 11.7 notes, or nearly four notes per week. This level of productivity compares favourably with other studies of knowledge building and CSCL studies that used online discussions to support knowledge-construction processes. For example, Chan, Lee, and van Aalst (2001) reported an average of 58.9 notes over 18 weeks in a first attempt at knowledge building by a grade 12 physical geography class (3.2 notes per week). In research by Hsi (1997), grade eight students wrote an average of 4.8 comments over the course of the semester. Further, in research on thirty-five university classes by Guzdial and Turns (2000), the average number of notes created ranged from 4.4 to 5.2. The percentage of notes linked to other notes (41.9%) was relatively low, compared both with the honours class and prior research on knowledge building (Chan et al, 2001). However, it would seem that if nearly one in two notes is linked to another note—i.e., is a comment or is the subject of a comment—there would be considerable opportunity for knowledge building. At the same time, it is important to note that there was evidence for a lack of participation in knowledge building processes in both classes: the percentage of notes read, scaffold use, and note revision all were low in both classes.

The between-group comparisons revealed that there were differences among groups on ATK measures, including Notes Created, Percentage of Notes with Links to Other Notes, Percentage of Notes Read, and Scaffold Use. The effects sizes were from moderate to large, and *larger than the between-class effects*. These results suggest that the between-group analysis provides a potentially useful lens for examining participation in knowledge building. The large effects obtained in this study indicate that it is crucial for understanding knowledge building to examine group features as moderating variables.

Results of the verbal analysis suggested that both classes demonstrated partial evidence for knowledge building via the nine knowledge building principles assessed. The total scores for the nine principles were essentially the same for both classes: 16.32 (60.4% of the maximum total score) for the mainstream class and 14.33 (53.1%) for the honours class. As expected, however, the evidence indicates that there was only partial evidence in both classes as the highest total score was only 60.4% of the total possible score. It is also worth recalling that for neither class there was evidence for the rise above principle.

CHAPTER 4:
IMPLEMENTATION 2

This chapter reports a follow-up study based on a second implementation of the inquiry unit by the same teacher, but with new grade ten mainstream and honours classes. The rationale for the follow-up study was three-fold. (1) In Implementation 1, the participants were not drawn randomly from populations of grade ten students enrolled in mainstream and honours social studies courses. Consequently, it is possible that the samples used were not very representative of these populations. In this case it is useful to examine if the findings of Implementation 1 can be reproduced in a similar setting and to base the conclusions on additional data. (2) Implementation 1 was the teacher's first implementation of knowledge building and Knowledge Forum. It is possible that some of the effects observed in Implementation 1 were simply artefacts of the teacher's inexperience in fostering knowledge building that could diminish with more experience. (3) Implementation 1 was studied after the students completed their work, and no instruments could be administered to measure variables that one would expect to moderate participation in online discussions.

During Implementation 1, in Spring 2004, the teacher was new to knowledge building. Since that time, the teacher was shown preliminary results from the study based on that implementation, was interviewed about his experience with Knowledge Forum, and gained additional experience with

Knowledge Forum. He had participated in several workshops on knowledge building in his school and at Simon Fraser University (SFU). In the semester following Implementation 1 (i.e., Fall, 2004), the teacher participated in a Knowledge Building Institute, a two-day conference on knowledge building for teachers held at SFU, where he presented the unit with four students from the honours class from Implementation 1. In the same semester he implemented the unit in a mainstream social studies course (he did not have an honours class). After this unit, the teacher was interviewed for the second time. In this interview, he described the change of understanding of knowledge building after these two units as follows:

> I think it (practising knowledge building) has made me aware of what I am doing day to day... the type of lecturing I am doing, the question I'm asking... all the assessment strategies that we are using, trying to ensure that they are working to improve the student achievement, and those principles of KB definitely meet, or define very well what we are trying to do in our courses...I think it's made me become more of a reflective practitioner on the daily base being aware that this is really a good strategy to make use of the instructional time that I have. (interview, Jan 7, 2005).

The data reported in this chapter were collected during the teacher's third iteration of working with Knowledge Forum. By this time, he had learned more about knowledge building, and had a better understanding of the knowledge building principles and how online discussions in Knowledge Forum can mediate learning. Minor procedural changes resulting from the teacher's growth and requests from the researcher are described later in the chapter.

The chapter repeats the analysis of participation with Analytic Toolkit and the analysis of knowledge building with the knowledge building principles for the

new classes. Further, additional data were collected to examine variables expected to moderate participation in knowledge building discourse. Two instruments were administered prior to the unit: a Writing Apprehension Test (WAT) and an Epistemology Questionnaire (EQ). Portfolios created by the students at the end of the unit were also analyzed. The rationale for measuring writing apprehension and epistemological belief is provided below.

Writing apprehension reflects students' attitude and emotion towards writing task and written communication. According to Brand (1986), the role of emotion in writing processes is important to study, because the affective and cognitive components of composing are interrelated. This association of cognition with feeling is known as "hot" cognition (Abelson, 1963). Knowledge building involves students writing into an asynchronous environment to contribute and communicate. The writings contains information about students' opinions, preferences, and evaluations. Because of the nature of computer supported asynchronous environment in knowledge building, if a student is to make his/her idea public, the written idea will be available for everyone to see forever. This emotional aspect of writing (writing apprehension) may explain why some students choose to write the minimum length and amount using safe language, whereas some write when they are not required to using more words and sophisticated language (Faigley, Daly, & Witte, 1981). Therefore, writing apprehension may have an impact on the knowledge building process. The extent of nervousness associated with writing may influence students' contribution to Knowledge Forum quantitatively and qualitatively. Research has

shown that writing apprehension is a good predictor of the quality of writing (Daly, 1978). In Daly's study, the writing apprehension test was administered to 3602 students. Findings showed that students with lower apprehension toward writing (those who felt less stressed when given a writing task), not only wrote differently, but also produced better quality of composition than those who had higher levels of writing apprehension. In Implementation 1, there was considerable variation in the amount of note creation, thus it would appear to be useful to examine if such variation persists if we control for writing apprehension.

Also along the lines of hot cognition, there has been growing interest in the last decade in the role beliefs about the nature of knowing and learning may play in learning (Hofer & Pintrich, 2002; King & Kitchener, 1994; Schommer, 1990). Such beliefs are referred to as *epistemological beliefs* and they have been assessed primarily with questionnaires, beginning with Schommer's (1990) questionnaire. The questionnaires have revealed the following components of epistemological belief: *certain knowledge* (absolute knowledge exists and will be known eventually), *simple knowledge* (knowledge equals to discrete facts), *omniscient authority* (authorities have access to otherwise inaccessible knowledge), *quick learning* (learning occurs either quickly or does not occur at all), and *innate ability* (the ability to acquire knowledge is endowed at birth instead of learnt). Although there is a need to go beyond questionnaires in studying epistemological beliefs, the subscales based on these components have been found useful for predicting performance on tasks such as thinking,

problem solving, and argumentative reasoning (Schraw, Bendixen, & Dunkle, 2002).

Learning to become a knowledge builder arguably requires advanced epistemological belief. For example, the belief that (expert) knowledge is "certain" contradicts the knowledge building principle that ideas are always refutable and subject to improvement; "omniscient authority" contradicts the knowledge building principle that students can and should examine authoritative sources critically; students who believe in "simple learning" may not recognize a need for the metacognitive work needed for the knowledge building principle that students can and should abstract general principles from a range of ideas (the "rise above" principle). All of these beliefs can be expected to influence how students participate in online discussions as well. For students who believe in "omniscient authority" and "simple learning," conducting research may be finding out and reporting what experts know; such students may not see a need for discussing at length what they are finding out.

The chapter first examines participation in the online discussions and the evidence for the knowledge building principles, as in Chapter 3. Following that, findings for the questionnaires and portfolios are reported and related to the ATK indices. The research questions were

1. How do students in mainstream and honours social studies classes participate in online knowledge building discourse?
2. How does participation in knowledge building discourse vary across groups of students who are collaborating, disregarding the level of the course in which the students in a group are enrolled?

3. Do the online discussions in both courses resemble knowledge-building discourse?
4. What relationships exist between participation in online discussions, writing apprehension, epistemological belief, and portfolio ratings?

Method

Participants

The participants were students in two classes—one mainstream and one honour—taking grade ten social studies at the same school as in Implementation 1, and from the same teacher. There were thirty students (fifteen males and fifteen females) in the mainstream class and twenty-six (eight males and eighteen females) in the honours class. English was a second language for 52% of students in the mainstream class and 35% of students in the honours course. In the mainstream class, 21% of the students were Caucasian, the remainder were minorities, most of them Asian. In the honours class, 42% of the students were Caucasian, and 50% Asian. There were no students with learning disabilities in either of the classes. In the mainstream class, one student had prior knowledge of Knowledge Forum, and in the honours class five.

Changes in Procedures

As explained in Chapter 1, the instructional design used for Implementation 2 was similar to that used for Implementation 1, which was described in detail in Chapter 3. In particular, the curriculum, the nature of the task, the use of collaborative groups, student evaluation, and the length of the

unit were unchanged. Here, I describe three *changes* in instructional procedures between the two implementations, which relate to the use of Knowledge Forum.

First, by request from the researcher, the teacher provided more similar training on Knowledge Forum for students in the mainstream and honours classes. Whereas in Implementation 1 only the honours class used practice views prior to beginning their inquiries, in Implementation 2 both classes used practice views.

Second, whereas in Implementation 1 each class had used its own database, in Implementation 2 both classes used the same database. The rationale for this change was that "social comparison" (Festinger, 1954) may take an effect so that more equivalent participation may occur for in both classes. According to Festinger's social comparison theory, when there are differences in ability between two groups there is a tendency to change oneself to move closer to others. The teacher encouraged students notes by the other class, but did not expect them to respond to such notes. This strategy seemed to have some effect. The Analytic Toolkit (ATK) analysis "Who's Read Whose Notes" revealed that the mainstream class read 6.5% of the notes written by the honours class, and the honours class 9.5% of the notes written by the mainstream class. Additional ATK analyses revealed that students did not comment on notes by the other class.

Third, in Implementation 2 the teacher provided more encouragement for students in the mainstream class to participate (interview, October, 5th, 2005). He emphasized to the mainstream class that he would monitor how many notes the students created and how the notes were linked as well as how the discussions

were developing. The teacher also used notes from the honours class as exemplary notes for the mainstream class. He used a projector in class showing the selected notes and discussed them with the students, explaining why these notes were chosen as exemplary.

Table 4.1 shows the group composition and topics (environmental problems). Groups A to D were from the mainstream class and Groups E to G from the honours class.

Table 4.1 Grouping Features

Mainstream [a]			Honours		
Group	Students	Topic	Group	Students	Topic
A	7 male, 0 female	Pine beetles	E	6 male, 2 female	Chernobyl
B	7 male, 3 female	Chernobyl	F	0 male, 10 female	Air quality
C	0 male, 8 female	Rain Forest	G	2 male, 6 female	Waste management
D	1 male, 3 female	Tar ponds			

[a] The mainstream class had one student who did not participate in the group discussion; he was excluded from the grouping. His parents did not give reasons for not agreeing to have their child to participate in Knowledge Forum discussion and he handed in a written report for the mark on this unit.

The final product used for student evaluation was a (paper-format) portfolio task designed by the teacher. (The teacher had also assigned these in Implementation 1, but they were not available from both classes for research.) Students were asked to identify two to three of their own notes and explain why they considered these notes as exemplary knowledge building contributions. Each note was accompanied by an explanation of its function in knowledge building discussions from three perspectives: content, context, and role. *Note content* showed evidence of students' own learning process and understanding

of the subject knowledge. Students were asked to demonstrate the evolution of their understanding from earlier notes to later notes. *Context* provided explanations of how each selected note helped to build the class's knowledge. This required students to explain how their notes functioned within the discussion thread by placing the notes in the context of the thread in which they appeared and explain how the notes fit in. For *note role*, students were asked to describe the roles their notes played in the discussion; explain how the notes clarified, elaborated, or extended the discussion; and/or provide a new way of looking at the issue under discussion. The portfolio also included a summary paragraph to outline students' experience through doing this project. In this paragraph, students wrote about what they had learned and if they found Knowledge Forum effective for learning about environmental issues.

Data and Measures

Analytic Toolkit (ATK) Indices

As in Chapter 3, the following Analytic Toolkit (ATK) indices were collected and analyzed for the views after the initial training task: Notes Created; Percentage of Notes Read; Percentage of Notes with Links to Other Notes; Note Revision; and Scaffold Use. The first two of these are productivity measures, while the last three are more specific to how students work in Knowledge Forum in relation to knowledge building concepts.

Knowledge Building Principles

A representative sample of discussions was analyzed using nine of Scardamalia's (2002) knowledge building principles, using the same procedures as in Implementation 1. First *z* scores of the ATK indices were calculated within each class, as well as a composite (average) z score for all the indices. All the writing by the group with the smallest composite *z* score was selected for the analysis. This methods selects the group that was most average in the class in terms of participation in the online discussions, as measured by the ATK indices. For the mainstream class the selected topic was "Pine Beetles" (128 notes) and for the honours class "Air Quality" (167 notes). As in Chapter 3, I explored these topics on the Internet using Google to determine if students could be expected to retrieve relevant documents for both topics. I used the topics (e.g., "Air Quality" to search. For both topics a large number of documents were retrieved: 43,200 for "Pine beetles" and 513,000 for "Air quality." Reading the first page of documents in the output, I satisfied myself that students had reasonable access to documents at a reading level accessible to grade ten students for both topics. The selected notes were then segmented into discrete discussions (5 discussions for the mainstream topic and 6 discussions for the honours topic) and each discussion coded using Law and Wong's (2003) rubric. As in Chapter 3, the principles "symmetric knowledge advancement," "pervasive knowledge building," and "rise above" were not used. The reliability of the rating procedure was determined in Chapter 3 and was 80% (Pearson correlation).

Writing Apprehension Test (WAT)

The Writing Apprehension Test (WAT) was administered at the start of the study. It consists of twenty Likert scale items, including the following: "My mind seems to go blank when I start to work on a composition", "I would enjoy giving my writing to magazines for evaluation and publication", and "Discussing my writing with others is an enjoyable experience." Such items reflect the extent of anxiety students have when faced with a writing task. Although some research has shown that some anxious writers are good writers (Bloom, 1980), most researchers agree that the writing apprehension test is an accurate tool in surveying writing apprehension (Reed, Burton, & Vandett, 1988). O'Neill and Sohbat (submitted), suggest that writing apprehension may influence online participation in Knowledge Forum. The scale reliability was very high for the questionnaires completed by the participants, indicating high consistency in the manner in which the items contributed to a single construct of writing apprehension (Cronbach alpha = .92).

Epistemology Questionnaire

An epistemology questionnaire was administered at the start of the study to examine the students' epistemological belief. The questionnaire used is a minor modification of a recent questionnaire by Conley, Pintrich, Vekiri, and Harrison (2004). The modification was made to change the questionnaire from a domain specific measure relating to scientific epistemology to a general measure of epistemology. It consists of twenty-six questions with five-point Likert scales from strong agreement to strong disagreement. The Cronbach alpha for the data

of this study was .82, which is acceptable; thus, the items on this questionnaire contribute reasonably to a single construct of epistemological belief. The data set was not sufficiently large to determine the component structure of this construct, so only the *total score* was used in the analysis. Each item contributes a score from 1 to 5 to the total score to indicate the strength of agreement of a response with knowledge building theory: A high score indicates strong agreement. Negatively worded items were recoded before the analysis. The questionnaire is provided in Appendix C.

Portfolio Assessment

Participants in both classes individually completed a (paper-format) portfolio task designed by the teacher. Students were asked to identify two to three of their own notes and explain why they considered these notes as exemplary knowledge building contributions. Each note was accompanied by an explanation of its function in knowledge building discussions from three perspectives: content, context, and role. By *content*, students showed evidence of their learning process and understanding of domain knowledge. Students were asked to demonstrate the evolution of their understanding from earlier notes to later notes in the portfolio. By *context,* students provided explanations of how each selected note helped to build the class's collective knowledge. This required that students explain how their notes functioned within the discussion by placing the notes in the context of the thread in which they appeared. By *role*, students were asked to describe the roles their notes played in the discussion; explain how the notes clarified, elaborated, or extended the discussion; and/or provide a

new way of looking at the issue under discussion. The portfolio also included a summary paragraph, in which students wrote about what they had learned and whether they found Knowledge Forum effective for learning about environmental issues.

All forty-six portfolios were rated by the teacher, using a marking scheme designed by the teacher. A second social studies teacher was trained on a small set of portfolios from Implementation 1, and then independently rated all the portfolios for Implementation 2, using the same evaluation criteria used by the teacher; she was not given any information about the class from which class a portfolio came. Analysis of inter-rater reliability revealed that the teacher assigned portfolio scores that were, for both classes, on average, 8 to 9 points (out of 50 points) higher than those assigned by the second rater. The inter-rater reliability was .66 (Pearson correlation). Although low—and something to improve upon in future implementations—this is not unusually low for portfolios (Koretz, Stecher, Klein, & McCaffrey, 1994).

Appendix D provides (a) the teacher's marking scheme, (b) the details of the reliability analysis, and (c) an example of how the marking scheme was applied to a portfolio. As the appendix elucidates, the measure obtained from the portfolio is primarily one that probes *summarization* and *reflection*. For example, "content" does not probe the correctness of claims relating to domain knowledge, but whether students are able to reflect on and formulate cogent arguments about the evolution of their ideas. Such skills are essential to knowledge building

and are represented by knowledge building principles such as rise above and epistemic agency.

Results

I begin again with an overview of the database. The mainstream class wrote 388 notes and the honours class 339. Of the 58 threads created by the mainstream class, 42 had fewer than 6 notes (72%); of the 54 threads created by honours class, 36 had fewer than 6 notes (67%). These general features of the databases are consistent with the teacher's impressions about participation levels. These statistics suggest that differences in participation between the classes were smaller than in Implementation 1. The honours class created fewer notes than in Implementation 1 (339, compared with 623).

This section reports findings for the four research questions and analyzes changes between Implementation 1 and Implementation 2. The alpha level was set at .01.

Between-Class Comparison of ATK Indices

The first research question was: "How do students in mainstream and honours social studies classes participate in online knowledge building discourse?" This question was addressed by a between-class comparison of the ATK indices.

Table 4.2 reports descriptive statistics for the five ATK indices for the two classes. The honours class had larger means for Percentage of Notes with Links,

Note Revision and Scaffold Use. However, the standard deviations for the last two measures were larger for the honours class than the mainstream class. Individual students in the mainstream class, on average, wrote 13.38 notes, or more than four notes per week—similar to Implementation 1; approximately one in two notes was linked to at least one other note. The percentage of notes read seemed low, as did Scaffold Use. For example, on average, students in the mainstream class used approximately one scaffold in 13 notes. The honours class used scaffolds more frequently than the mainstream class, but still infrequently compared to the number of notes written—7 scaffold uses in 13 notes. If scaffolds are used consistently, one would expect at least one scaffold use per note.

Table 4.2 Basic Knowledge building Indicators for Mainstream Class and Honours Class

	Mainstream		Honours	
	Mean	SD	Mean	SD
Notes Created	13.38	8.16	13.23	9.89
% Notes Read	12.86	8.21	12.12	5.76
% Notes with Links	41.86	32.74	62.00	22.77
Note Revision	3.34	3.86	8.88	9.17
Scaffold Use	1.21	2.37	6.69	7.47

A multivariate analysis of variance (MANOVA) of the data in Table 4.2 was conducted to compare the basic ATK indicators for the two classes. The five ATK indices significantly differentiated the two classes, F (5, 49) =10.94, p<.001, Wilks' Λ=.47, η^2=.53. Accompanying this overall effect were small univariate effects for: Percentage of Notes with Links, F (1, 53) =6.86, p=.01, η^2=.12; Note

Revision, $F(1, 53) = 8.86$, $p<.005$, $\eta^2=.14$; and Scaffold Use, $F(1, 53) = 14.08$, $p<.001$, $\eta^2=.21$. Observe that contrary to Implementation 1, no significant between-class effect was found for Notes Created.

Between-Group Comparison of Analytic Toolkit Indices

The second research question was: "How does participation in knowledge building discourse vary across groups of students who are collaborating, disregarding the level of the course in which the students in a group are enrolled?" This question was addressed by a between-group comparison of the ATK indices. Table 4.3 reports the descriptive data of ATK indices. Groups A to D were from the mainstream class, and groups E to G from the honours class.

Group B from the mainstream class had means that were larger than some groups from the honours class. For example, for Notes Created and Percentage of Notes Read Group B had the largest means of all seven groups from both classes. Percentage of Notes with Links was larger for Group B than for Groups E and F. Additionally, group differences were observed not only between classes but also within each class. For example for Notes Created, Group B not only outperformed groups A, C and D from the mainstream class, but also all groups from the honours class. Groups and data shown in bold letters in the table were selected for verbal analysis.

Table 4.3 Mean (SD) ATK Indices for Groups A-G

Group	Notes Created	% Notes Read	% Notes with Links	Note Revision	Scaffold Use
A	**14.9 (5.9)**	**15.9 (2.5)**	**47.6 (37.9)**	**2.7 (3.5)**	**1.4 (2.2)**
B	19.3 (9.6)	21.2 (3.7)	67.1 (26.4)	5.9 (4.7)	0.9 (2.5)
C	7.6 (2.5)	4.1 (2.9)	15.9 (10.1)	1.8 (2.0)	0.9 (1.7)
D	7.5 (1.7)	4.3 (0.5)	20.8 (14.3)	1.3 (1.9)	2.3 (3.9)
E	7.8 (4.1)	7.6 (2.9)	59.4 (19.3)	4.5 (3.4)	3.6 (3.7)
F	**16.7 (13.5)**	**14.1 (7.1)**	**59.0 (30.3)**	**12.9 (12.3)**	**5.1 (6.6)**
G	14.4 (6.8)	14.1 (3.5)	68.4 (15.2)	8.3 (7.1)	11.8 (9.3)

Groups A-D were in the mainstream class and E-G the honours class; Groups and data in bold letters were selected for verbal analysis.

MANOVA results showed that there were some differences among the ATK indices: Wilk's Λ = .08, F (30, 178) = 5.21, p<.001, η^2 = .40. The univariate effects were: Notes Created, F (6, 48) = 2.68, p=.02, η^2 = .27; Percentage of Notes Read, F (6, 48) = 19.31, p<.001, η^2 =.70; Percentage of Notes with Links, F (6, 48) = 5.52, p<.001, η^2 =.41; Note Revision, F (6, 48) = 3.02, p= .01, η^2 =.29; and Scaffold Use, F (6, 48) = 4.86, p<.001, η^2 = .37. Note that, as was the case in Implementation 1, most of the univariate effect sizes (η^2) were larger than for the between-class comparison. For example, for Percentage of Notes with Links it was .41, compared with .12 in the between-class comparison.

Verbal Analysis of Discussions Using Knowledge Building Principles

The third research question was: "Do the online discussions in both courses resemble knowledge-building discourse?" To investigate this question, a sample of views was coded with Law and Wong's (2003) rubric based on Scardamalia's (2002) knowledge building principles, as described in the methods

section. There were 5 discussions for the mainstream class topic "Pine beetles" with 128 notes and 6 discussions with 167 notes for the honours class topic "Air quality". The results are presented in Table 4.4. In the table, I also report the rank of each principle.

Table 4.4 Discussion Quality Scores

Knowledge building Principles	Pine beetles (Mainstream) (n=5)		Air quality (Honours) (n=6)		Rank
	Mean	SD	Mean	SD	
Community knowledge	3.00	.00	3.00	.00	1
Democratizing knowledge	3.00	.00	3.00	.00	2
Idea diversity	3.00	.00	2.83	.41	3
Epistemic agency	3.00	.00	2.67	.52	4
Real ideas	2.60	.55	1.83	.75	5
Embedded and transformative assessment	1.80	1.10	1.83	.75	6
Knowledge building discourse	1.80	.84	1.50	.55	7
Improvable ideas	1.80	.84	1.50	.55	8
Constructive uses of authoritative sources	.60	.90	1.50	.84	9
Total score	20.60	4.23	19.66	4.37	–

Principles such as community knowledge, democratizing knowledge and idea diversity had very high scores for both classes. Almost all discussions were assigned full scores for these three principles. Improvable ideas and constructive use of authoritative sources had relatively low scores for both classes. Ordering of the accessibility of the knowledge building principles was the same for the two classes, but it was different from Law and Wong's (2003) study. Epistemic agency, real ideas, and embedded and transformative assessment had higher scores in this study than in Law and Wong's study.

Compared to Implementation 1, the quality of discussions by both classes provided stronger evidence for knowledge building. The overall mean of the scores for the nine principles was higher than in Implementation 1 (e.g., 20.60 for the mainstream class, compared with 16.32 in Implementation 1). The improvement in the quality of the discussions was not limited to principles which had high scores in Implementation 1. For example, scores were low in Implementation 1 for epistemic agency, real ideas/authentic problems, and embedded and transformative assessment, but scores for all these principles were medium to high in Implementation 2.

Writing Apprehension, Epistemological Belief, and Portfolio

The fourth research question was: "What relationships exist between participation in online discussions, writing apprehension, epistemological belief, and portfolio ratings?" This question is addressed in three parts. (1) Results are reported for the Writing Apprehension Test, epistemological questionnaire, and portfolios. (2) The analysis of variance of the ATK indices is then repeated using the first two measures as covariates. This will reveal whether significant differences remain significant when the influence of these variables is taken into account. (3) Correlations among all measures are then examined for the between-class comparison.

Writing Apprehension

Descriptive statistics for the Writing Apprehension Test are reported in Table 4.5. A *higher* score indicates less anxiety toward writing. Because

knowledge building is realized through written communication in Knowledge Forum, students' writing apprehension may impact their performance in the discussions in Knowledge Forum. A one-way ANOVA revealed that students in the honours class were statistically less anxious about writing than students in the mainstream class, F (1, 50) =10.7, p<.005, η^2=.18. This result appeared to indicate a *general* dislike of public writing. Evidence for this can be found by examining the items with the largest between-class differences. For example, mean scores for "I like to write my ideas down," "I like seeing my thoughts on paper," and "I would enjoy giving my writing to magazines for evaluation and publication," all had between-class differences of approximately one standard deviation.

Table 4.5 Descriptive Statistics for Writing Apprehension Test

	N	Minimum	Maximum	Mean	SD
Mainstream	27	29	80	60.3	12.2
Honours	25	46	91	72.0	13.4
Total	52	29	91	65.9	14.0

Epistemology Questionnaire

Descriptive statistics for the epistemological belief measure obtained from the epistemology questionnaire are reported in Table 4.6. A higher score indicates more advanced beliefs about the nature of knowledge, including beliefs that knowledge is constructed and improvable, rather than absolute and fixed. A one-way ANOVA showed that students in the honours class, on average, had more advanced beliefs than students in the mainstream class, F (1, 50) =13.0,

$p<.005$, $\eta^2=.21$. Although the data set was too small to confirm the components of epistemological belief reported in the literature (Schommer, 1990; Schraw, Bendixen, & Dunkle, 2002), the most relevant components appeared to be *certain knowledge* and *nascent authority*. For example, there was a one standard deviation difference between the classes for the item "An answer to questions is either right or wrong" (certain knowledge); there was.79 standard deviation difference between the classes for the item "There are some questions that even experts cannot answer."

Table 4.6 Descriptive Statistics for Epistemology Questionnaire

	N	Minimum	Maximum	Mean	SD
Mainstream	29	90	124	101.3	6.2
Honours	23	98	128	108.4	7.9
Total	52	90	128	104.4	7.8

Portfolio Scores

The portfolio scores are assumed to probe reflection and summarization, as explained in the method section. I report the ratings by the independent rater; these had more variance than the teacher's ratings, and I was more confident that they had been applied consistently across the mainstream and honours classes (see Appendix D for details). Results show that students in the honours class outperformed students in the mainstream class (see Table 4.7). A one-way ANOVA showed this effect was statistically significant, F (1, 44) =7.6, $p<.01$, $\eta^2=.15$.

Table 4.7 Descriptive Statistics for Portfolio Scores

	N	Minimum	Maximum	Mean	SD
Mainstream	23	13	50	33.6	9.7
Honours	23	23	50	40.6	7.3
Total	46	13	50	37.1	9.2

Influence on ATK Indices

To investigate the influence of the writing apprehension and epistemological belief scores on the significance levels for between-class and between-group comparisons of the ATK indices, I conducted a series of multivariate analyses of variance with the ATK indices as dependent variables: (a) with no covariates, (b) with the writing apprehension score as covariate, (c) with the epistemological belief score as covariate, and (d) with both covariates.

For the *between-class comparison* there were two changes in the results: The significant difference between the classes for Note Revision was no longer significant at $p<.01$ when the writing apprehension score was used as a covariate: F (1, 49) =3.89, p=.054, η^2=.07. Presumably if students did not like to write, they were less likely to return to a note to revise it. In addition, the significant difference between the classes for Percentage of Notes with Links was no longer significant when either writing apprehension (F [1, 49] = 5.17, p=.03, η^2 =.10) or epistemological belief (F [1, 49] = 4.57, p = .04, η^2 = .09), was used as a covariate, or when both were used as covariates at the same time (F [1, 45] = 4.19, p = .05, η^2 =.09). Presumably students are less likely to refer or write about

other people's ideas under the intention to improve ideas, if they do not like to writing or do not think of knowledge as something that can be improved.

For the *between-group comparison*, the significant effect for Note Revision was long longer significant at if either or both of the covariates were used. The change in the significance level was greatest when both writing apprehension and epistemological belief were used as covariates, F (6, 40) =1.93, p = .10, η^2 =.23. This indicates that students who both dislike writing and perceive knowledge as static are less likely to revise their ideas once posted.

These findings suggest that individual differences in writing apprehension and epistemological belief are important variables for accounting for the variation in participation across groups.

Correlations among Measures

To examine relationships among the variables, the ATK measures were aggregated to create a general ATK measure. This was the average of the *z* scores for the five indices, calculated using data from both classes. Table 4.8 shows Pearson correlation coefficients for the composite ATK score, writing apprehension, epistemological belief, and portfolio score. The upper entry in a given cell is the correlation for the mainstream class, and the lower entry the correlation for the honours class.

Table 4.8 Pearson Correlation Coefficients [a]

	Writing Apprehension	Epistemological Belief	Portfolio
Epistemological Belief	.07 .40		
Portfolio	.48* -.02	.16 .34	
Analytic Toolkit	-.03 .42*	.10 -.09	.35 .23

[a] Results for the mainstream class are the upper entries and for the honours class the lower entries in each cell.
* $p < .05$ (2-tailed).

For the *mainstream class*, there was a moderate and significant correlation between writing apprehension and portfolio score, $r = .48$, $p<.05$. Thus, in this class, 23% of the variance in portfolio scores could be predicted from writing apprehension (r^2). For the *honours class* there was a similar correlation between writing apprehension and the composite ATK measure, but this was not significant at $p < .01$. The results indicated that writing apprehension had moderated influence on students' performance involving wiring not only on paper-based tasks but also on online writing tasks.

Changes in the ATK Indices from Implementation 1 to Implementation 2

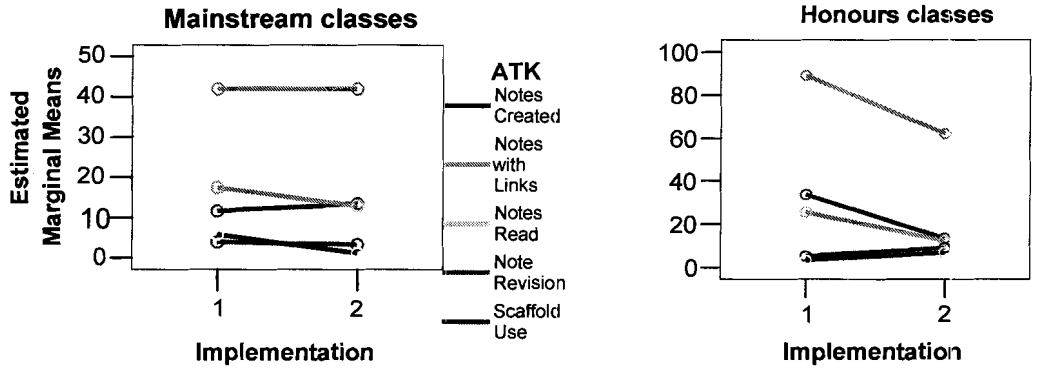
Some changes in the results pertaining to research question 1 are apparent. For example, in Implementation 1 there was a large gap between the two classes for Notes Created, which was much smaller in Implementation 2. The teacher first noted that the honours class of Implementation 2 was, in his opinion, "not as good" as the one in Implementation 1. For this reason, it is

worthwhile to test whether any apparent improvements were statistically significant or due to chance.

A repeated measures ANOVA was conducted of the ATK indices for the two implementations. The classes in Implementation 1 and 2 were treated as independent samples, but each ATK index was treated as a repeated measurement on the same subjects. The within subjects factor consisted of five levels, one for each ATK index. The between-subjects factors were Class and Implementation.

The results revealed a small change from Implementation 1 to Implementation 2, F (1,109) =11.98, p =.001, η^2 =.10. The Implementation by ATK interaction was significant (F [1,109] = 14.10, p <.001, η^2 =.12), as was the Implementation by ATK by Class interaction (F [1,109] =45.10, p <.001, η^2 =.29). The latter three-way interaction is shown in Figure 4.1.

Figure 4.1 Estimated Marginal Means of ATK Measures



For the honours class most of the indices decreased (e.g. Notes Created, Percentage of Notes Read, and Percentage of Notes with Links to Other Notes). This is consistent with the teacher's interpretation that the honours class in Implementations 2 was not as good as the one in Implementation 1. In other words, the large gaps between mainstream and honours classes observed in implementation 1 were not stable. For the mainstream classes the ATK indices remained more or less constant, suggesting that the changes in procedures in Implementation 2 did not affect the extent of participation, although verbal analysis suggests that discussions by both classes were stronger relative to the knowledge building principles.

Summary

The goal of the study reported in this chapter was to follow up Implementation 1 with two new classes of students, but using essentially the same instructional design. I asked the teacher to make some modifications to the instructional design of Implementation 1 to provide similar instruction in mainstream and honours courses. This study additionally collected data for two moderating variables and examined knowledge building portfolios developed individually by students in both courses.

The results of the statistical analyses of the ATK indices were similar to those obtained in Implementation 1, except that the gap between the mainstream and honours classes in terms of Notes Created and Percentage of Notes Linked to Other Notes was smaller. There were few large differences between the

classes on the ATK indices. In addition, as in Implementation 1, group membership generally explained more variance of the ATK indices than class membership. The changes in instructional procedures and the teacher's additional experience appeared to produce only small effects on the ATK indices. The findings for the verbal analysis using the knowledge building principles were similar for both classes but suggest an improvement over Implementation 1. The total scores were 20.60 (76.3% of the maximum total score) for the mainstream class and 19.66 (72.8%) for the honours class. However, it was still partial evidence (the highest score was only 76.3% of the total possible score), and there was no evidence for the rise above principle.

Although the analyses of the ATK indices suggest that group variables are as important to consider than class variables, students in the honours class outperformed students in the mainstream class on all three of the new instruments: writing apprehension, epistemological belief, and portfolios (summarization). These findings suggest three areas where work with students in mainstream classes may improve participation levels. Using writing apprehension and epistemological belief as covariates removed several significant effects in the analyses of the ATK indices. Analysis of the correlations suggested that writing apprehension had influence on students' performance for both online writing and the portfolio task. Influence on portfolio scores was limited to the mainstream class and influence on Analytic Toolkit scores to the honours class.

CHAPTER 5:
DISCUSSION

I began the thesis by discussing a new field in educational research: computer-supported collaborative learning (CSCL). In CSCL, collaborative learning is supported by technology that can enhance interaction among participants and work in groups (Lipponen, 2002). CSCL approaches are based on social constructivism, highlighting individual and distributed aspects of cognition (Salomon, 1993). Although some CSCL approaches have been implemented for years in classrooms in which there is substantial within-class variation on achievement, motivation, and so on (e.g., Linn & Hsi, 2000; Scardamalia, Bereiter, & Lamon, 1994; White & Fredericksen, 1998), teachers remain questioning whether most students in their classes will participate in such interactions. Therefore, I examined participation levels in asynchronous online discussions in the context of a CSCL approach known as knowledge building (Bereiter, 2002; Bereiter & Scardamalia, 1993; Scardamalia, 2002). The research questions were

1. To what extent do students in mainstream and honours social studies courses participate in online knowledge building discussions?
2. How do participation levels vary across groups of students who are collaborating, disregarding which in which class students in a group were enrolled?

3. Do the online discussions in both courses resemble knowledge-building discourse?
4. What relationships exist between participation in online knowledge building discussions, writing apprehension, epistemological belief, and portfolio ratings?

The thesis investigated these questions in two three-week implementations of knowledge building in grade ten social studies mainstream and honours classes.

This chapter discusses the findings from the two implementations, relating them to the problem that differential participation levels may produce a barrier to wide-scale implementation of knowledge building. The first section summarizes the findings. The goal here is not so much to compare the studies as to identify what may be learned about the problem from both. The second section discusses limitations of the thesis. The third section relates the findings to the barrier problem and makes several suggestions for teaching and further research.

Summary of Findings

Table 5.1 summarizes the main findings from the two implementations. For simplicity, I do not report detailed statistics but categorize the findings using Cohen's (1988) classification of effect size: *large* (η^2=.40), *medium* (η^2=.25), and *small* (η^2=.10). In the paragraphs following the table, I highlight the key effects.

Table 5.1 Summary of Findings

	Implementation 1	Implementation 2
	Large effects : none *Medium effects:* % Notes with Links *Small effects:* none	*Large effects:* none *Medium effects:* none *Small effects:* % Notes with Links, Note Revision, Scaffold Use
Between-class comparison of ATK indices	• Mainstream: Notes Created and % Notes with Links met expectation • Honours: Notes Created very high; % Notes with Links beyond expectation • Both classes: % Notes Read, Note Revision, & Scaffold Use below expectation	• Mainstream: % Notes with Links somewhat below expectation • Honours: % Notes with Links at expectation • Both classes: % Notes Read, Note Revision, & Scaffold Use below expectation
Between-group comparison of ATK indices	*Large*: Notes Created, % Notes with Links, % Notes Read, Scaffold Use *Medium*: % Notes with Links *Small*: none	*Large*: % Notes with Links, Scaffold Use *Medium*: Notes Created, Note revision
Knowledge building principles	Total score Mainstream:16.2 Total score Honours: 14.33	Total score Mainstream:20.6 Total score Honours: 19.6
Relationships among variables	Not done	WAT, EQ, and Portfolio: Honours > Mainstream WAT: predicted Portfolio

Note: relationships among variables were not examined in Implementation 1.

Between-class comparison of ATK indices. In Implementation 1 there were large differences between the means for the mainstream and honours class for Notes Created and for Percentage of Notes with Links. However, the first of these effects was not stable across implementations. All classes were relatively productive. For example, the mainstream class in Implementation 1 wrote approximately four notes per week. In both implementations, scores for

Percentage of Notes Read, Note Revision, and Scaffold Use were low for both classes.

Between-group comparison of ATK indices. The key finding in both classes were that the effect sizes were generally larger than for the between-class comparison. For example in Implementation 1, Percentage of Notes with Links was a large effect in between-group comparison, but it was a medium effect for the between-class comparison.

Knowledge building principles. In all classes there was partial evidence for the knowledge building principles; there did not appear to be noticeable differences between the mainstream and honours classes. For Implementation 2 the evidence was somewhat stronger than in Implementation 1. However, this finding must be interpreted cautiously because only a small sample of the discussions was analyzed.

Relationships among variables. Relationships among variables were examined in Implementation 2. The key findings in both classes were that writing apprehension and epistemological belief modified the between-class and between-group effects on ATK measures. This suggests that when controlling statistically for these two variables, differences are reduced in both the between-class and between-group comparisons of the ATK measures. For example, in the between-class comparison, Percentage of Notes with Links to Other Notes was no longer an effect when either or both of writing apprehension and epistemological belief were used as covariates. Correlation analysis of variables

also showed that in the mainstream class, writing apprehension predicted portfolio scores.

Limitations of the Study

The thesis has some limitations common to classroom-based research. Implementation 1 used a pre-experimental design (without controls), and Implementation 2 a quasi-experimental design (with covariates as statistical controls). In neither study were participants assigned randomly to the conditions. Consequently, the findings may have limited generalizability.

A more serious limitation was that I chose to select the writing of only one group per class for the verbal analysis using the knowledge building principles. This choice was made because the labour-intensive nature of the rating process. An analysis based on all the discussions would have made the findings more compelling.

In order to be able to interpret the between-group differences, it would also have been useful to examine how the students were functioning within groups as social entities. From a social psychology perspective, groups are important to study because a group has a profound impact on individuals by shaping their actions, thoughts, and feelings. Also at the sociological level, individuals define their identities, beliefs, and values through membership in groups (Forsyth, 1999). The synthesis of the two studies gave rise to new questions of how and to what extent the group dynamics can predict students'

success in knowledge building, using measures that exist, not necessarily exclusively, but independently from CSCL and knowledge building theories.

Discussion and Implications for Research

What arguments can the thesis offer to a teacher who is sceptical that most students in a typical high school class can participate in online knowledge building discussions? Within the above-mentioned limitations of the thesis, several points can be made.

Variation in Participation Levels

In both implementations group membership explained more of the variance in the ATK indices than the mainstream-honours distinction. This finding contradicts the assumption noted in Chapter 1 that primarily high-achieving students would participate in online discussions. One possible interpretation is that collaborative groups differ in how they use the online discussion environment. For example, if one group uses online discussions as a method for collaborative meaning-making and another group uses it to report what it is finding out without much meaning-making (or doing it offline), we would be likely to observe substantial between-group differences in the number of notes created, the percentage of notes linked to other notes, and other ATK indices. In other words, these ATK indices are difficult to interpret as objective measures of participation in the knowledge building process. In addition, one class can differ substantially from another class with respect to observed ATK indices. Teachers know that an instructional unit that is effective with one class may not be so with another class at the same academic level. In this thesis, large differences in Notes Created and

Percentage of Notes with Links to Other Notes observed in Implementation 1 were not observed in Implementation 2.

Adequacy of Participation Levels

The observed differences in participation levels, between the mainstream and honours class in Implementation 1, as measures by the ATK indices, played an important role in the teacher's perception about the suitability of online discussions for students in mainstream courses. However, in both implementations it was suggested that participation levels by the mainstream classes should be adequate for knowledge building to occur. Note creation at a rate of nearly four notes per week compares favourably with the literature (Guzdial & Turns, 2000; Hsi, 1997; van Aalst & Chan, 2001), especially if one considers that students were not evaluated based on productivity measures. Further, although only a sample of discussions were analyzed with the knowledge building principles, higher ATK indices did not appear to be associated with better performance on the knowledge building principles. To the contrary, in Implementation 2, Notes Created and Percentage of Notes with Links to Other Notes *decreased* while the scores for the knowledge building principles *increased*.

Although further research is needed to identify a statistical relationship between the ATK indices and the knowledge building principles, my findings suggest that the ATK indices used in these studies may not be a very effective probe of participation in the knowledge building process. If confirmed by further analysis, this finding is important because its designers posit the ATK as a tool

students can use to examine their own knowledge building discourse with an aim to improve it. Anecdotal evidence suggests that when students see output from the ATK their reaction frequently is to write more notes or comment on notes more frequently, but such efforts may not produce better knowledge building discourse.

Effects of Design of Use of Knowledge Forum and Teacher Experience

The teacher made minor changes to the instructional design in Implementation 2 relating to the use of Knowledge Forum. These included: (a) providing training on Knowledge Forum for the mainstream class through practice views; (b) using a shared database for the mainstream and honours classes rather than separate databases, and encouraging students to read notes by their peer class; and (c) providing more encouragement to the mainstream class to participate. The repeated measures analysis in Chapter 4 did not suggest these changes led to substantial improvements in participation as measured by the ATK indices (see Figure 4.1).

The observed improvement in the scores for the knowledge building principles is difficult to interpret, but one hypothesis is that it was mediated by improvements in the teacher's understanding of knowledge building theory. As mentioned in Chapter 4, the teacher participated in a conference on knowledge building between the two implementations. To prepare for this conference, he and a panel of students from the honours class in Implementation 1 reviewed their database using several knowledge building principles, and that may have been a particular experience that mediated his learning about knowledge building.

Clearly, more research is needed to examine how teachers learn to facilitate knowledge building. However, it has been suggested that it is necessary that teachers work to establish a culture in which collaboration and idea improvement are encouraged over time (Chan & van Aalst, 2003; Cummings, 2003). For example, an elementary school teacher at another school said in an interview after several months of knowledge building in a fourth grade class:

> The role of the teacher in a knowledge building classroom is one of raising the spirits, motivating and creating an atmosphere such that there is a willingness of students to participate in conversation. In order for this to be genuine, the teacher must be seen as an equitable facilitator of students' ideas. The teacher listens carefully, and learns along with the students when to interject ideas, when to encourage the shy to speak...With such teachers, children are involved in exciting educational enterprises and make the greatest growth in language learning and conceptual development (Cummings, 2003, p. 6).

For this teacher, it is not only important to encourage students to *participate* in the conversation but also to facilitate a quality of conversation in which he helps students to express their ideas and in which the teacher is learning along with the students. Another teacher works with students over time to help them develop cognitive strategies that are needed in a collaborative culture, such as summarization and consolidating opposing views (Chan & van Aalst, 2003).

Moderating Variables

The findings indicate that students in the honours class in Implementation 2 outperformed students in the mainstream class on measures of (lack of) writing apprehension, epistemological belief, and summarization (through the portfolio).

The analysis of the correlations indicates that for the mainstream course writing apprehension was an important variable moderating participation.

It is necessary to examine how these gaps between the achievement levels can be reduced. For example, van Aalst (1999) found that students who created notes that revealed misconceptions early in an inquiry unit ended up writing more sophisticated explanations by the end of the unit than students who only rarely created such notes early in the unit. He attributed this effect to prior knowledge (i.e., avoidance of being embarrassed by posing incorrect information), but it may also apply to, or be partly explained by, students' attitudes toward *writing* for a public audience. Slater and van Aalst (2002) found that high school students for who English was a second language did not like writing into Knowledge Forum because their "mistakes" would be available for their peers to see and would be so as long as the database was accessible. These studies suggest that the teacher needs to do considerable work with students to develop a culture in which "making mistakes" is not only acceptable, but recognized as something that can mediate conceptual progress—the "learning from your mistakes" dictum. Sophisticated student (and teacher) views about knowledge and learning, characterized here as "epistemological beliefs," and summarization skills are also important to address.

Further research that examines the relationship between knowledge building and what I have called the moderating variables in the other direction would also be interesting. For example, does experience at knowledge building lead to more sophisticated views about the nature of knowledge and learning? As

I suggested in Chapter 3, the study of epistemological belief is still in its infancy. Knowledge building may provide a useful context for studying how epistemological belief change occurs, particularly knowledge building over longer periods of time than studied in this thesis. The demonstration of positive effects regarding epistemological belief change would, I suggest, make arguments for knowledge building more compelling.

Adequacy of the Knowledge Building Principles

In this thesis, I used the knowledge building principles to evaluate qualitative evidence for knowledge building. In both implementations there was substantial evidence for most of the principles. However, several important principles were excluded from the analysis. This raises questions such as the following: Can we say that we have knowledge building without evidence for the "rise above" principle?

Such questions are important question because there is anecdotal evidence to suggest that many teachers find the knowledge building principles difficult to understand or implement when they are first introduced to them, and may focus on a small subset. Where do they begin, and can they achieve knowledge building that way? Scardamalia (2002) posits that the knowledge building principles constitute a *system*. It is suggested that research is needed to determine the structure of that system. Which principles contribute most to knowledge building outcomes, and which variables moderate them?

Conclusion: From Participation to Engagement

When I began the thesis, I conceptualized a barrier to widespread implementation of knowledge building in terms of participation. The mainstream and honours social studies classes studied here provided a good setting for exploring this barrier. Findings from ATK indices indicate that the mainstream-honours distinction was limited for understanding participation because (a) there were larger between-group differences and (b) the mainstream-honours differences were not stable across the implementations. In addition, the evidence for knowledge building via the knowledge building principles was similar in both types of course.

The analysis of Implementation 2 indicated that there did not exist a strong relationship between the ATK scores and the portfolio scores; although based on a sample of the data, there also did not appear to be a relationship between the ATK indices and scores on the knowledge building principles. The first of these findings is surprising because prior studies have identified significant correlations between ATK scores and portfolio ratings (Lee, Chan, & van Aalst, in press; van Aalst & Chan, 2001); however, in those studies portfolios were based on a set of principles describing knowledge building (not the principles used in the thesis) and in Implementation 2 they were not.

I tentatively conclude that "participation," as measured by the ATK indices I used, has limited utility as a concept for studying the implementation potential of knowledge building. Although productivity---the creation and reading of notes—is clearly important, it needs to be coupled to high *engagement* with knowledge

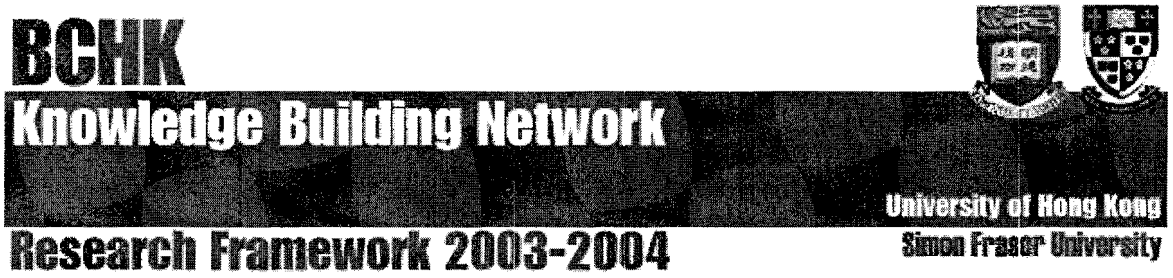
building concepts. An example of the type of engagement I have in mind is how a reflective portfolio task can *scaffold* the knowledge building process—it informs students about when and how to contribute to the discourse (Lee et al, in press).

This change of terminology reflects that knowledge building is not primarily about creating and reading notes but about idea improvement and advancing the frontier of knowledge in a community (Scardamalia, 2002). Psychological models involving knowledge building concepts may elucidate the components of the needed engagement and how the teacher may facilitate the knowledge building process. In the absence of such models, however, there appear to be few differences between students at different academic levels relating to the knowledge building principles.

APPENDICES

Appendix A: Research Forms: Information and Consent

Teacher Information



INFORMATION FOR IKIT TEACHERS

This document provides a summary of the current research agenda of the Institute for Knowledge Innovation and Technology (IKIT), and describes how we can contribute to and benefit from it.

IKIT's goals

IKIT is a global organization committed to developing educational experiences that help to prepare students for participation in societies in which knowledge building and innovation are pervasive. IKIT is trying to understand the "developmental trajectory" of knowledge building—how do people learn it? To understand knowledge building it is often useful to look at how people in companies learn (e.g. Nokia, 3M, various Japanese companies, etc.), how scientists and artists learn on the job, and so forth. Marlene Scardamalia has articulated a set of twelve "determinants" (principles) of knowledge building. IKIT has identified a number of barriers to knowledge building, and the goal of IKITs research is to go "beyond best practice" and break some of those barriers. (We could identify additional barriers.)

IKIT sees work with teachers in a novel way. Teachers and researchers are seen as working on the same educational problems. Teachers bring their knowledge of classrooms, subject areas, etc. to bear on the problems; researchers are more concerned with creating new knowledge of a more academic type. In other words, educational theory is not created by researchers alone—who usually are out of touch with classrooms—but is created in collaboration with teachers to make sure that educational theory reflects real classrooms and is relevant to real classrooms. Teachers often are co-authors on conference papers.

An example of what IKIT has in mind is the work with Mr. Lee around knowledge building portfolios (see our virtual tour, proxy.ikit.org/20004/). The portfolios were first introduced in a graduate course, but then improved by Mr. Lee in his classes. Mr. Lee really took charge of the idea and gave it the level of detail that was necessary for his students. When Carol Chan and I became interested in what he had done, Mr. Lee made his class available for interviewing, gave interviews himself, and cooperated in writing conference papers about his class's work. He was listed as a co-author on those papers because his classroom work made the conceptual advances described possible. Mr. Lee then went on to attempt the portfolios with younger students. Mr. Lee's work has now also been extended by Ivan Lam and has been a motivating force behind some work at OISE as well. In other words, *Mr. Lee has contributed to knowledge building through his teaching, study of knowledge building, and thought about his teaching.* He also has benefited from these experiences, for example by having his work recognized internationally.

Barrier-Braking Innovation in IKIT

The key thing that we are participating in is a four-year IKIT project called "Beyond Best Practice: Research-Based Innovation in Learning and Knowledge Work." At a general level the IKIT proposal promises four innovations, described below.

- *Focus on idea improvement:* There are probably two key distinctions here. The first is a distinction between a focus on task completion and a focus in which understanding ideas is central. In the first case, students may learn what it takes to get an A (getting an A is the objective); in the second case, students focus on understanding the ideas and doing well on a test is just an indicator of that. The second distinction has to do with how students see *ideas*. In learning, ideas often belong to other people, and students are trying to understand other people's ideas. In knowledge building, students see that the ideas themselves can be improved—that they are not static, true, or whatever, but that they have a history and future, and have value to a community's practice.
- *Comprehending difficult text as a task for collaborative problem solving*: Often students read texts especially prepared for them (e.g. at a lower reading level). IKIT wants to show that students can learn from materials that have not been modified this way.
- *Controlling the time demands of on-line teaching and knowledge building:* Knowledge building takes more time. One of the key challenges is to show that knowledge building works well in contexts that are dominated by standardized assessment, full curricula, etc. So we could try to make a case that the curriculum can be "covered" in a defensible way; you could also try to make a case that there is a strong relationship between what students do in school with KF and skills needed for work or skills needed for postsecondary education.
- *Building on intuitive understandings:* Most constructivist teachers teach a pre-defined curriculum starting from what students know? Can you create a curriculum *based on* what students know? In this area, it is important to understand the fate of misconceptions. What kind of progress do students make to understand scientific, social, language arts, etc., concepts?
- *Shared problem spaces as a basis for cross-age, cross-sector learning and knowledge creation:* I think that our network can only address this peripherally. One area could be to develop tools that can be used across such sectors. For example, how can the ATK be used to guide teacher development? Our way of working together as a network is another potential contribution.

A more specific look at barriers to knowledge building (from IKIT web pages)

A barrier-breaking innovation makes possible something that was widely thought to be impossible before. There are many worthwhile innovations in education and knowledge work that do not have that character—adopting a new technology, finding a novel use for existing technology, designing an exciting new learning activity, improving on an existing practice—but the IKIT Scholars program is aimed at encouraging those rarer innovations that do break barriers. In particular, it is aimed at overcoming barriers to knowledge building in education and organizations. Some of the common barriers to knowledge building are these:

Age barriers:

"They're too young..."
"They're too old... [to do such and such]."

Motivational barriers:

"This may be fine for people who are highly motivated, but for the average [student, worker]...."

Aptitude and learning style barriers:

"This is only for the gifted... creative... well-educated...."--for special types of learners, for special types of intelligences, not.....

Socio-economic barriers:

"This is only for certain classes of people, not..."

Cultural/national/ethnic barriers:

"This may work in [Toronto, noncompetitive cultures, different societies] but not in..."

Difficulty and complexity barriers:

"It's too hard..." "Beyond their level."
"I don't fully understand it myself."
"Too abstract."

Regulations and accountability barriers:

"I'd like to, but we're required by [our board, the public, my boss]..."
"This doesn't fit with the guidelines."

Priority barriers:

"Knowledge building is valuable, but we have to give first priority to [skills, meeting deadlines, mastering essential content, etc.]"

Domain and context barriers:

"This may work in... [science, health care, schools, our design department] but not in... [history, customer service, sales]...

Time barriers:

"Our work is fast-paced. We're too busy with more urgent matters to deal with knowledge building."

Sufficing barriers:

"We are doing fine with our current methods. We just need to tweak those a bit."

Risk barriers:

"We need to get our scores and production up first, and then we will be ready for something new"

"Let's stick with the tried-and-true and wait for more data before we make changes."

Doing versus thinking barriers.

"We are not the idea/design people, we are the producers."

Our goals for Year 1

Within British Columbia there may be up to four KF servers. One server will be operated by Pinetree Secondary School, one by New Westminster Secondary School (a maximum of two databases), one by the Nanaimo-Ladysmith School District (site license), and one by the Pitt Meadows-Maple Ridge School District (two databases). My assumption is that these servers are provided to make progress toward the above-mentioned IKIT objectives. Nevertheless, not every database on a given server need be used to meet IKIT goals.

In what follows, I will break down what I think it means to be contributing to the IKIT agenda in our first year.

New teachers

For teachers new to knowledge building and KF, the goal for the first year is to learn to teach with KF. These teachers may or may not develop databases that can be researched to meet IKIT goals, depending on their level of comfort with that. Teachers may choose to open their databases only to the local research team, and not to the wider IKIT community. In addition to using KF, these teachers commit to the following:

- Learning more about knowledge building;
- Obtaining parental consent for the IKIT project;
- Collecting adequate information about what students are learning about the problems they are studying and analyze such information.

More experienced teachers

I would expect that the following would be feasible for teachers who already have some experience with KF:

- Learning more about knowledge building;
- Aligning their current work with KF with the IKIT goals (barrier-breaking innovations)
- Collecting adequate information to identify progress toward personal goals set this way;
- Obtaining parental consent for the IKIT project;
- Collecting adequate information about what students are learning about the problems they are studying and analyze such information.

In other words, these teachers create *personal action plans* to improve (or replicate) knowledge building in their classes or come to understand it better. Personal action plans begin from teachers' own experiences and interests, *but they are articulated with IKIT goals*, so that progress made can be reported as progress toward IKIT goals. As we see more clearly the direction such personal action plans take, we can apply to the IKIT Scholars Program for additional resources.

All teachers

In addition you will be asked for consent to the use of any video and audio data that involves you. Each teacher will be interviewed about once per year to develop a sense of how your thinking about teaching, knowledge building, and KF is developing.

The hybrid culture of teaching and research in IKIT

IKIT is a partnership between teachers and researchers. It is crucial that you do not see yourself as someone who just "provides data" to an external project (the usual situation in educational research). *Instead, you need to see yourself as someone who invests in and owns part of the IKIT*

mission. If you are part of IKIT for the right reasons, you are intrigued by what knowledge building has to offer to education and have an interest in seeing it develop further. "Developing it further" requires that we have more success stories from classrooms and a more fully developed educational theory, so that we will be in a position to begin addressing the large-scale changes that are needed. The success of this project depends on teachers and researchers seeing themselves as part of the same mission to improve education; success is co-owned by all who work hard to achieve it.

Although we are a community we do not do everything together, and there is a division of labor. In IKIT, teachers teach. But their teaching, and use of KF, is framed by the notion of knowledge building, and there should be regular occasions in which teachers and researchers come together to talk about challenges, evaluate current experience, and so forth. Researchers have three roles. The first, and most important to them, is to analyze as much data as possible and write up studies. This helps both to give recognition to the work teachers do and to create much-needed knowledge. The second role is to provide professional development opportunities and opportunities to learn from teachers' classroom experience. The third role is to provide occasional assistance to teachers between such events. I discuss preliminary plans for the second and third roles next for the first year.

Community events:

- *One face-to-face meeting.* Because it will take some time to get started in classrooms, I plan to have one face-to-face meeting with all teachers in the project in in BC, which will be scheduled for January or February. Where necessary, I will seek funding for release time for this meeting. The meeting would have a mix of presentations (recent theoretical advances and classroom experience), sessions to work on specific problems, and practical workshops on KF.
- *3-4 Virtual meetings.* Each of these is a one-hour conference call (with web-based videoconferencing where available), and is devoted to a specific problem. Participants may include teachers, some students from your classes, and some of the IKIT teachers who work in different locations around the world. Each "meeting" will be preceded by some online work in a network database to begin the discussion (over a period of 3-5 days).

Ongoing support for classroom work:
In the past, I have tried to visit classrooms regularly (about every second week), but that approach has met with limited success. Our experience in Hong Kong has been that such regular visits are not necessary if teachers have had considerable training (e.g. graduate courses related to learning, instruction, IT, and have further opportunities for professional development). So, I am inclined to look at classrooms at a more course-grained level—as follows.

- I am willing to come out early in your work with new students, if desirable to the teacher, to meet the students. The basic idea here would be to be able to put a face to the students writing notes, explaining the larger context behind KF.
- Toward the end of your work with a group of students, I would like to interview the students. Very likely, I would record a whole class discussion, but sometimes it will be better to interview individual students. These interviews are not based on a few short experiences, but on quite a lot of work with KF (a year or semester). So, students can look back on what they have learned about subject matter, about how they learn, and about knowledge building. I would also interview teachers approximately once per year.

All this data would be used primarily for developing *virtual tours* in which we use student and teacher perspectives on knowledge building.

- My research assistants and I will regularly watch all the databases, and where desired, run ATK analyses. We will try to do this *on demand*, that is, responding to specific questions you have about your own database. With *email notification* in KF 4.5.1, it should be easier to keep track of developments in databases.
- I will try to "check in" with 1-2 teachers each week, but teachers should also feel free to ask for help when more help is needed.
- I strongly suggest that you develop your own "network" of teachers within IKIT and consult with them as needed. There is experience "out there" that you can learn from. I will maintain the network database we used last year, and if you think it is useful, you can self-organize and use that to have specific discussions on problems you need to solve.

Student Consent Form

SIMON FRASER UNIVERSITY

FORM 5: PROJECT INFORMATION DOCUMENT

Project: Beyond best practice: research-based innovation in learning and knowledge work
Place: Canada (British Columbia) Hong Kong
Chief researcher: Dr. Jan van Aalst, Faculty of Education, Simon Fraser University, 8888 University Drive, Burnaby, BC, V5A 1S6, vanaalst@sfu.ca

Participants: The participants in this study are students in a several elementary and secondary classrooms in British Columbia and Hong Kong. Students will write into a database (Knowledge Forum) as part of research projects that their class is conducting. One or twice a semester, students may also be interviewed about their experiences with this database system; video of such interviews will be recorded. Participants also allow researchers to use their assignments, tests, and provincial tests for the study.

Overall Goals of Study: 1) To disseminate research-based educational practices that put knowledge building and innovation central. 2) To enhance the knowledge base about how this approach works in the classroom.

Risks to the subject, third parties or society: There are no risks associated with this project. Previous studies have shown that students benefit considerably from the knowledge building approach. Writing is improved, as well as understanding the topics students are studying. Students also learn about how they learn (i.e. develop skills that help them do better in school).

Benefits of experiment or project to the development of new knowledge: The expected benefits of the research to new knowledge are as follows. (1) I seek to enhance the impact of an innovative educational approach called knowledge building. We want to implement this approach to a wide variety of school subjects and school types. (2) I also wan to learn more about how this approach performs on traditional measures of success in education. So I need to build up more evidence that knowledge building strategies promote achievement on teacher-designed and provincial tests.

How confidentiality and anonymity will be assured: The following people have access to the database that students write into. 1) Students in the class of the student in question. 2) SFU researchers working on the project. Real names will be removed, and replaced by codes, before storing information from assignments, teacher tests, and provincial tests. First names cannot be removed from (occasional) video recordings, and therefore video recordings are not completely anonymous. But they are confidential and we are not asking for consent to publish video excerpts with this consent form. (If we wish to publish video, we will ask consent for this with another consent form.) All data will be stored securely on the university campus.

Participation by students in this project has been approved by the school district and the school principal.

Appendix B: Discussions Evaluation

Part A: Rubric for evaluating discussions using knowledge building principles

KB Principles	Evaluation criteria
Community knowledge	• All group members shared responsibility for contributing regularly to advance the work of the group • Ideas provided should contribute to the collective goal and of value to others
Democratizing knowledge	• All members contribute to the discussion without over-dominating, valuing others' contribution • There is a relatively even contribution of notes from each member
Idea diversity	• The variety of ideas contributed by the group of students • The ability to provide additional information that are relevant to the problem though not necessarily directly related
Epistemic agency	• Theory construction: the group shared the responsibility for the advancement of knowledge • Theory refinement: members compare and contrast the ideas contributed by each other
Kb discourse	• Idea revision, knowledge refinement and idea-improving process observed • Good use of KF features like reference, annotation, scaffold, etc. to facilitate scholarly communication
Improvable ideas	• Students give comments and critique to others' contributions, and look for further improvement between their ideas and those of others • The existence of theory refinement, revision and continual improvement
Real ideas	• The ability of students to turn their own ideas or problems into a researchable question • The quality of the investigation
Constructive uses of authoritative sources	• Use authoritative sources • Build-on and supplement other sources • Keep a critical stance on information sources • Generate bibliographies for the referenced sources
Embedded and transformative assessment	• The ability of members to perform internal assessment, self-evaluation and review on progress • Contribute notes to reflection journal • Ability to correct, fine-tune and improve study plan

a. A discussion refers to a group of notes presented to clarify a complete idea (see details in the following paragraphs).

b. Adapted from Developmental trajectory in knowledge building: An investigation, by N. Law and E. Wong, 2003. In B. Wasson, S. Ludvigsen, & U. Hoppe (Eds), *Designing for Changes* (pp. 57-66). Kluwer Academic Publishers. Printed in the Netherlands.

Part B: Example: Scoring of Epistemic Agency

According to the table in the previous section, epistemic agency consists of two elements: *theory construction* and *theory refinement*. On the rubric, a "1" would indicate that evidence for neither feature is moderate to strong, a "2" that evidence for both features is moderate or it is moderate to strong for only one, and a "3" that evidence for both is moderate to strong.

Consider first the following discussion excerpt; indentation signals that a note is a response to the note above it. The discussion had 27 notes, but not all are shown. The letters identify different students and the numerals the position of the note in the discussion.

9 (A). My solution!
    10 (B). Good idea, but too idealistic?
        11 (C). Time consuming
        12 (A). Different perspective
    13 (D). My opinion of your solution
        14 (A). Research
            15 (D). Misunderstanding?
                16 (A). I understand
                17 (D). Well

In (9), student A proposed a solution: "...a man made virus should be exposed to the beetles which would make them...carry it on to other beetles...This would then kill the beetles!! ..." This note initialled the idea construction activity in this discussion. In (10) student B stated, "Making a virus is harder than it seems... funding is a major problem..." This note showed the attempt at idea refinement. However, the next entries wandered away from this effort, saying that there is not enough time to do the research (11), (13). As a result, student A did not put

additional arguments to continue constructing the theory; instead, she posted note (12) stopped trying to defend her idea: "...You have outlined some great points, but a solution that has successfully worked has not occurred yet... Possibly not my suggestion of a solution...This note shifted the attention of the group from either continuing constructing or refining the theory.

This excerpt provided some but limited evidence for both theory construction and theory refinement. The evidence for epistemic agency was relatively weak according to the rubric. It received a score of 1 according to the rubric in the last section.

The following excerpt received a score of 2 to the principle of "epistemic agency" according to the rubric. In the same discussion as above, there was an episode of theory construction, where the group shared the responsibility for the advancement of knowledge.

18 (A). Clear Cut Harvesting
19 (D). I don't agree
20 (C). Bad for the ecosystem
21 (A). Clear cutting
22 (A). Brood tree removal
23 (D). I agree
24 (A). Possible end to beetle?
25 (E). More trouble
26 (A). Burning of trees
27 (F). What they are doing to our forests

Student A drew the idea of "clear cut" on a negative point of view in note (18), " The idea of clear cut harvesting covers the large area of forest and involves cutting down all trees, but can result in scarring the land." There were several "for" and "against" notes upon this idea. Student D stated in (19): "I think

that even if this method consumes a considerable amount of time, it is the best we can get...we can get unemployed people to do this job..." Student A also posted a supporting note (21) on this, making her ideas more dialectic: "I have to agree with D. This solution involves funding and involvement BUT has many positive effects also..." Other group members joined in this theory building process by providing facts and data to either agree or disagree with the ideas (student C, E, and F).

The idea was carried on to a point that clear cut harvesting can do both good and harm to the environment, and the viable solution should focus on reducing the harm. However, the terminal of the development of this idea was at students' finishing combining ideas together and reaching a conclusion. The depth of the discussion was still limited because students were simply weighing the exiting factors without elaborating any further. Therefore the evidence for idea refinement was still weak.

The following discussion received a score of 3 to the principle of "epistemic agency" according to the rubric. In view of "pine beetle extra information", there was an eleven-note discussion on anti-freeze. The hierarchies of the notes are shown as follows:

1 (G). Pine Beetle does have Anti-Freeze
2 (G). Cold Snap in October or November
3 (A). No anti-freeze?
4 (G). Glycerol is the Anti-freeze
5 (A). Much better!!!
6 (F). Yes or no
7 (A).They do...
8 (F).Its right...
9 (G).Confusing...
10 (C).NO SENSE! lol
11 (G).It does make sense

Student G started the discussion in note (1), "... without this Glycerol, they will die due to the cold temperature." He then built on himself providing more facts to support his own idea (2): "Pine Beetle builds their GLYCEROL... starts around mid November until December..." The idea was introduced from factual knowledge on the subject of pine beetles. Student A built on this idea in note (3) to challenge the reliability of the information provided by G. This challenging stimulated the refinement of the theory and promoted the construction of a theory that is publicly accepted. Student G then explained to A and confirmed his own ideas in note (4). And student A was convinced at last by the reasoning and giving of examples by student G, she agreed with G in note (5). Afterwards, student A helped to explain G's idea to another student when he seemed confused on whether pine beetles had anti-freeze or not (student F in note 6). Other group members participated in this theory construction (C and F) and finally the group agreed on a conclusion in a summary note (11) by G.

In this discussion, the process of idea construction and refinement was very clear on how pine beetles survive brief cold weather by questioning,

explaining and critiquing each other's thoughts. An idea started from a doubtful statement, but ended by a conclusion and theory that was agreed upon by all group members.

Appendix C: Epistemology Questionnaire

The Hong Kong Community College

Epistemology Questionnaire

Purpose

This questionnaire has a number of questions about your views about knowledge in general. Do not spend a long time on each item" your first reaction is probably the best one. Please answer each item. Your answers are **CONFIDENTIAL**.

Instructions

1. Use a **blue/black ball-pen** to fill in the oval completely:

   Right: ● Wrong:⊗ ◐

2. Please fill in the appropriate circle to indicate your level of agreements about yourself.

⑤ = Strongly agree (SA) ④= Agree (A) ③=Neutral (N) ②=Disagree (D) ①=Strongly Disagree (SD)

		SA	A	N	D	SD
1	Everyone has to believe what experts say.	⑤	④	③	②	①
2	All questions have one right answer.	⑤	④	③	②	①
3	Some ideas today are different than what experts used to think.	⑤	④	③	②	①
4	I make judgments about competing theories based on available information.	⑤	④	③	②	①
5	I always believe what the textbooks say about stuff.	⑤	④	③	②	①
6	What is true today will be true tomorrow.	⑤	④	③	②	①
7	The ideas in textbooks sometimes change.	⑤	④	③	②	①
8	There can be more than one way to test new ideas.	⑤	④	③	②	①
9	Whatever the teacher says in class is true.	⑤	④	③	②	①
10	Knowledge will not change over time.	⑤	④	③	②	①
11	There are some questions that even experts cannot answer.	⑤	④	③	②	①
12	It is good to try experiment more than once to make sure of your findings.	⑤	④	③	②	①
13	If I read something in a textbook book, I can be sure it is true.	⑤	④	③	②	①
14	Once the experts have a result for a question, that is the only answer.	⑤	④	③	②	①
15	New discoveries can change what we think is true.	⑤	④	③	②	①
16	Good answers are based on evidence from various sources of information.	⑤	④	③	②	①
17	Only experts know for sure what is true.	⑤	④	③	②	①
18	Answer to questions is either right or wrong.	⑤	④	③	②	①
19	Good ideas can come from anybody, not just from experts.	⑤	④	③	②	①
20	It is no need to find out more evidence to support well-known theories.	⑤	④	③	②	①
21	I just accept answers form experts even if I don't understand the reasons why.	⑤	④	③	②	①
22	Too many theories just complicate things.	⑤	④	③	②	①
23	New ideas can come form your own questions and experiments	⑤	④	③	②	①
24	Correct answers are more a matter of opinion than facts.	⑤	④	③	②	①
25	Where multiple opinions exist the experts will eventually decide which is correct.	⑤	④	③	②	①
26	Good answers are those with rigorous analysis and evaluation.	⑤	④	③	②	①

Appendix D: Portfolio Evaluation

Part A: the teacher's marking scheme

A portfolio of 3 to 4 notes of your best contributions to the knowledge building in the class. Select notes which you feel particularly demonstrate the quality of your contribution to the KF class discussion. In order to find 3 to 4 exemplary notes, you will need to have contributed actively to the discussion during the ongoing study of your group's topic. For each note in your portfolio, you should include the following information:

A) C o n t e x t

For each portfolio note, provide an explanation of how this note helped to build the Class's knowledge. This means you will be explaining how your note functioned within the thread. Place the note in the context of the thread in which it appears (i.e. What is the thread subject or topic and how does your note fit in).

B) R o l e

Describe your note's role in that discussion. Explain how the note has clarified, elaborated and/or extended the discussion, and/or provided a new way of look at the issue under discussion.

Here are examples of the types of contributions:

Brainstorming - introducing of new ideas that relate to the topic or task

Analysis - comparing or contrasting previously articulated views or puts new understanding on existing ideas

Articulation - explaining complex or difficult concepts

Reaction - providing an alternative or amplified perspective on a concept previously introduced

Organization - assembling existing thoughts or perspectives in such a way that new or clarified perspectives emerge

Generalization - takes ideas already presented and extracts new ideas that can apply to a broader set of conditions

You will need to explain how your note fits into one (or possibly more) of these categories and identify why that was helpful to the discussion given the context you identified earlier.

C) C o n t e n t

Each of your portfolio notes will also be marked for the quality of the content you included. The notes will function as evidence for of your own learning process as your understanding of the environmental topic evolved during the discussion. The selection of notes should indicate that evolution from earlier notes to later notes where presumably your understanding of the topic deepens. You should include your thoughts on the solutions that your group has developed.

D) Summary Paragraph

In a paragraph outline the learning that you have experienced through doing this project. Talk about any new information gained. Did you find

Knowledge Forum an effective forum for learning about environmental issues? This is your opportunity to tell me what you have learned.

Part B: the inter-rater reliability analysis

For the mainstream class the portfolios included two notes, and for the honours class three notes. The teacher explained that he thought the mainstream class would not have sufficient time to complete three-note portfolios. All forty-six portfolios were rated by the teacher, using the marking scheme described in part A of this appendix. A second social studies teacher independently rated all the portfolios, using the same evaluation criteria used by the teacher; she was not given any information about the class from which class a portfolio came.

Repeated Measure ANOVA Results

Effect	SS	df	MS	F	p	η^2
Rater	1592.4	1	1592.4	64.72	.000	.60
Rater × Class	19.9	1	19.9	.81	.374	.02
Error	1082.5	44	24.6			

This table shows the ANOVA table for the within subjects effects for a repeated measures Rater by Class ANOVA. As the table shows, there was a strong Rater effect F (1, 44) = 64.72, $p < .0005$, η^2=.60. In fact, the teacher assigned portfolio scores that were, for both classes, on average, 8 to 9 points (out of 50 points) higher than those assigned by the second rater. At the same time, little variance was associated with the Rater by Class interaction. Thus, although the teacher systematically assigned ratings that were higher than those assigned by the independent rater, there did not appear to be systematic bias

toward one or the other class. However, the sample Pearson correlation coefficient between the two sets of ratings, which could be taken as a measure of inter-rater reliability, was low: $r = .66$. Low inter-rater reliabilities are not unusual for portfolio evaluations (Koretz, Stecher, Klein, & McCaffrey, 1994), and generally reflect the complex nature of the assessment task and what it attempts to assess.

Part C: an example for marking scheme application

In this section, an example is given on how the marking theme for portfolios was applied. The following portfolio was created by a male student from the mainstream class in Implementation 1; it received a total mark of 44 out of 50 (88%). The student was a member of the group investigating the topic of Pine beetles. He chose three of his own notes as exemplary to demonstrate how the notes were useful to the group discussion and what he had learned during the knowledge building process.

In the following paragraphs, I give details on why this portfolio was warded for the mark. The total 50 marks were assigned to three aspects according to the rubric: for each note, content of note, context of note and role of note were examined for a total mark of 5 for each aspect. Another 5 marks was assigned to the summary paragraph.

Notes 1 and 2 (the student's own notes) were clearly stated, and included well-thought-out, informative entries. Note 1 received 4 marks, note 2 received 5 marks, and note 3 received 3 marks for content of note. The student identified the context of each note by showing how the note connected to the thread/group

discussion it was included within; All three notes received 5 marks out of 5 for context of note. It was clear how this information helped to build the group's knowledge. For example, Note 1 – "The note was a starter note that led to more discussion about the rapid growth of the mountain pine beetle." Note 2 – "It added information into the form by telling people about the blue stain that comes from the fungus inside the beetles." For role of note, the role of each note was reasonably explained in terms of the note's contributions to the discussion, although the phrases identified on the assignment (e.g. brainstorming, analysis) were not used: "The role this note played was to add onto information from someone else's note in the thread" (Note 2). Therefore note 2 received 4 marks for role of note and note 1 and 3 were awarded 5 for role of note. The summary paragraph was done to an average, reasonable level – a few things learned were identified, both in terms of content and Knowledge Forum process knowledge without describing or explaining any of them in too much detail. For example: "The reasons for this were because, if a poster had to be done, I would have felt that I would have researched more to make the poster better." (This response did not address why completing a poster rather than using KF might have produced better research.) As well, the flow of the paragraph lacked smooth connections. "Some things I learnt were: How bad the pine beetle problem is, ways to prevent the spread, ways it affects the economy and many other things." Therefore the summary paragraph received 3 marks out of 5.

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