# "Constantly Going Deeper:" The Knowledge Building Innovation in an Elementary Professional Community

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## Abstract

Sustainable learning innovation requires the development of strong, innovative teacher communities. Through analyses of interview data, reflection journals, and field observations, this ethnographic study investigated how teachers at an elementary school sustained the knowledge building innovation. Key conducive factors identified included: (a) Shared visions and deep ownership of teaching practice, coupled with deep trust in students' agency and potentials; (b) A hybrid identity that connects teaching with research; (c) Dedicated efforts to deepen pedagogical understanding, evolve designs, and break barriers; (d) Collaborative emergence in classroom practice; (e) Dealing with the complex reality in classroom while maintaining a focus on innovation and improvement; (f) Professional dialogues and apprenticeship; and (g) Strong leadership support for innovation.


## Introduction

Schools of the 21st century need to prepare students for a knowledge-based society in which creative and collaborative knowledge work pervades. Over the past two decades, a number of inquiry-based, collaborative learning programs have emerged with the goal of developing students who can work productively with knowledge and ideas (e.g., Brown & Campione, 1990; CTGV, 1996; Edelson, Gordin, & Pea, 1999; Hmelo & Lin, 2000; Krajcik, Blumenfeld, Marx, Bass, & Fredricks, 1998). Making these innovations sustainable and scalable in schools represents a major challenge. According to Brown and Campione (1996), the most difficulty part of this challenge is the enactment of the first learning principles underlying an innovation. Without adherence to first principles, learning innovations are often ritualized and degraded as a set of surface procedures when they are adopted at scale.

Deep, sustainable learning innovation requires the innovative capacity of teachers (Fishman, Marx, Blumenfeld, Krajcik, & Soloway, 2004). It replies on the development of strong, innovative teacher communities who have ownership over the innovation and capacity to sustain, spread, and deepen the underlying principles (Coburn, 2003). A reality however is that teacher communities in schools often strengthen traditional

teaching and discourage innovation and change (McLaughlin & Talbert, 2001). What characterizes an innovative teacher community that can enact sustained improvements and innovations in practice? How can such a community be developed in a school? Recent literature suggests that learning innovation can be better sustained by a community that engages teachers' collaboration and sharing in practice, collegial dialogues about student learning, and friendly critics (Fogleman, Fishman, & Krajcik, 2006; Phillips, 2003); that encourages teachers' continual learning, deliberate investigation, risk-taking, and reflection on enactment (Krajcik, Blumenfeld, Marx, & Soloway, 1994; Wilson & Berne, 1999); and that gives teachers autonomy and authority in classroom- and school-related decision-making (Vescio, Rossa, & Adamsa, 2008). Sawyer (2004) went further to underline the importance of improvisation in creative teaching. Creative teaching aimed at facilitating student knowledge construction/co-construction needs to embrace a higher level of improvisation, with the flow of the class emerging from the actions and interactions of students and the teacher. Further research needs to better understand the above and additional essential conditions based on rich data collections in specific contexts of learning innovations (c.f. Little, 2002).

The present study looks into the knowledge building innovation enacted by teachers at an elementary school—Institute of Child Study (ICS) Laboratory School in Toronto. The goal of the knowledge building innovation is to prepare students for a knowledge-based society in which knowledge creation pervades. In a knowledge building community, students' ideas come to the center and gain a public life, being continually revisited, critically examined, applied, revised, re-organized, and risen above (Scardamalia & Bereiter, 2006). The knowledge building pedagogy represents a principle-based approach to learning innovation (Brown & Campione, 1996). Knowledge building in classroom is guided by a set of 12 principles, for example, *authentic problems and real ideas, collective responsibility for community knowledge, improvable ideas, epistemic agency, knowledge building discourse, idea diversity, constructive use of authoritative sources, embedded and transformative assessment*, etc. (Scardamalia, 2002). The knowledge building process is further supported by Knowledge Forum®, a computer-based collaborative knowledge building environment (Scardamalia, 2004). Knowledge Forum provides a communal space that allows students to share their understanding and to work together to continually improve the ideas represented there. They build onto each other's ideas to achieve deeper understanding and higher levels of conceptualizations. Classroom discussions and offline activities help to frame and give definition to online work. For example, students discuss diverse ideas through face-to-face, knowledge building discourse, conduct experiments and observations to advance

their theories, search libraries and the Internet for reference material, spend a great deal of time reading. They record and share new resources and discoveries in Knowledge Forum, and improve their ideas through online discourse.

The knowledge building pedagogy and technology have been implemented at ICS over a decade. Recent studies analyzed the knowledge building initiatives facilitated by ICS teachers over the past years, and demonstrated sustained, significant advances in practice. Improvement was reflected in increasing individual contributions to collective knowledge resources and taking collective responsibility for knowledge advancement (Zhang & Scardamalia, 2007; Zhang et al., under review). Recognizing its innovative capacity, Bielaczyc and Collins (2006) identified ICS as a hotbed community for developing and sustaining innovations in learning and teaching. Knowledge building at ICS represents a telling case of deep, sustained, school-wide innovation. The purpose of this study was to understand major factors (e.g., structures and processes) that enable sustained innovation among ICS teachers, bringing to light basic conditions for knowledge building—as well as other learning innovations that take a principle-based approach—to take roots and grow in a specific school context.

## Method

### The School

ICS is a laboratory school affiliated to the University of Toronto, located in downtown Toronto, Canada. It was established in 1926, partly inspired by the work of John Dewey. Currently it enrolls students from Nursery (Pre-K) to Grade 6, with each classroom having 22 students on average. As a laboratory school, it has a strong connection with the University and has been involved in initiating and disseminating new ideas related to improving education. It also makes daily contributions to teacher training, providing internship opportunities for graduate students in the programs of child development and education. The knowledge building pedagogy was first adopted at ICS in late 1990's, beginning with two teachers, and has become a school-wide innovation over the past decade.

### Data Sources and Analyses

The participants in this study were the Principal and 10 teachers of ICS who have been extensively using the knowledge building pedagogy and technology in teaching. The Principal has been on this post for over a decade. Among the 10 teachers, there were eight classroom teachers teaching Nursery (Pre-K), Kindergarten, and Grades 1-6; one teacher working in the library; and one physical education teacher. Four of the teachers

had been conducting knowledge building for over three years; four were in the second year, and two were in the first year of using the knowledge building pedagogy.

We conducted this ethnographic study to understand major factors that enable the sustained knowledge building innovation at ICS. The data sources included:

(a) Field observations. Over two years, the first three authors sat in the weekly knowledge building/Knowledge Forum meetings—1.5 hours each week—where the teachers and the Principal talked about their advances and challenges. We also conducted intensive observations in the Grade 1 and 2 classrooms for a year and a Grade 5/6 classroom for two years, to understand how the teachers conducted knowledge building with students of different ages.

(b) Semi-structured interviews with the teachers and the Principal. Each interview took approximately 40 minutes, focusing on the role of a teacher, goal of teaching, teaching advances, challenges, and school support (See Appendices 1 and 2 for the interview protocols). The interview data were transcribed for comprehensive coding.

(c) The teachers' reflection journals shared online, called "Calendars of Inquiry (COI)." The teachers recorded their knowledge building designs, classroom processes, and reflections on advances and problems.

Our systematic data analyses conducted so far focused on the interview data, with data from field observations and the teachers' reflection journals helping us to triangulate and interpret findings from the interview data. Following the process of inductive data analysis (Hatch, 2002; Strauss & Corbin, 1998), two coders read and re-read the interview data, coded their responses to the interview questions, and identified salient domains—major factors that enable and sustain teachers' knowledge building innovation. Each salient domain was represented by identifying "included terms" (members of a category) and their "cover term," followed by a search for connections across the domains. Comprehensive data analyses are still underway; below are preliminary findings from the analyses we have conducted.

## Results

The analyses of the interview data, teachers' reflection journals, and field observations revealed a wide range of specific efforts, strategies, and resources that contributed to the teachers' sustained improvement and innovation, as well as specific challenges the teachers encountered in different contexts. However, there are seven salient domains/themes that are compelling and coherent across the participants. The salient domains are summarized in Table 1 and elaborated below.

Insert Table 1 here

**Epistemic Agency: Shared Visions, High Expectations, and Deep Ownership**

To understand their visions of teaching, our interviewers asked the teachers and the Principal to identify three most important qualities they would like to develop in their students and explain how they develop those qualities. While the specific phrases they used varied, the teachers and their Principal indicated important, shared goals they attempt to accomplish, including: developing students' social characters such as confidence, caring, respect, and collective responsibility; intellectual curiosity and enthusiasm; and self-directed, deepening inquiry of knowledge. Their approaches to teaching focus on creating an open, student-centered environment and a respecting, responsible, and reflective community that can help each student learn, inquire, and grow in all the above areas. These shared visions about learning and teaching represent important cohesive factors that connect members in a strong professional community (McLaughlin & Talbert, 2001; see also, Sarason, 1971).

As an essential force driving their continual innovation of practice, the teachers and the Principal all hold high expectations about what young students can accomplish in knowledge building and collaboration. They build the trust that children can take on high-level responsibility, including responsibility for generating meaningful questions and themes to deepen their inquiry, for contributing and collaboratively improving their ideas, and for reflecting on and improving their thinking, participation, and collaboration. The teachers communicate their trust and expectation to students through daily classroom interactions, with accepting idea diversity and taking collective responsibility for sharing and improving ideas as social norms in classroom.

> *I want the students to make independent, purposeful choices about how they spend their time in the class. So when they are presented with questions, or a bunch of materials, or an open time frame, that they can be thinking in a very purposeful way about how they're going to pursue it … I want them to be knowing that they can act independently, they don't need to have a teacher there, guiding them in the whole way, and telling them what they're doing is right or wrong* (interview data, a Kindergarten teacher commenting on the important qualities she wants to develop among her students).

> *The other thing is … a feeling maybe of empowerment that they are able to contribute knowledge that they have something worth saying, not everything we say is going to be accurate but it is worth saying anyway…When you realize what you thought wasn't accurate you say: 'Oh, wasn't that interesting? I thought this way. But now I think in a new way.' And along with this empowerment comes this understanding that theories that are improvable, the theories that are presented in a textbook or in a lesson are the theories that simply have the most, the best research to support them but there are other existing theories or other theories that haven't yet been yet presented that might improve upon that idea and that the students themselves might be the people who contribute that knowledge.* (Interview data, a Grade 5/6 teacher commenting on the important qualities she wants to develop among her students)

Through reflective observations of students' knowledge building, the teachers are often impressed by the level of thinking and work students are able to accomplish. They continually envision new possibilities in student learning and development, and thereby identify new possible areas to improve their practice.

> *… My soul gets constantly amazed by what these young children can accomplish...* (A Kindergarten teacher commenting on the important qualities she wants to develop among her students in the interview)

> *… Trusting the child's power as learner. Sometimes in presenting a question and stepping away, the children can take hold and go in directions that I can't imagine.* (A Grade 4 teacher who was using Knowledge Forum for the first year, commenting her improvements of teaching in the interview)

Associated with their understanding of student agency and potentials, the teachers adjust their role so that students can take on high-level control in classroom. They create open, safe, and supportive environments where students can be active contributors of knowledge. In the interviews, the teachers were asked to identify three most important advances they had made in their teaching practice. Understanding young students' agency and adjusting their role as teachers accordingly is a compelling theme emerging from their responses.

> *… When I first tried out KF [Knowledge Forum] in my classroom, I experienced a seismic shift in my belief in how children in the early years can share ideas in order to come to a deeper understanding… Over the years, I have consciously worked on ways to release agency in a classroom of pre-k children in a way that is meaningful to them.* (A Pre-K teacher reflecting on her major advances in teaching in the interview)

Along with their strong belief in students' agency over learning and knowledge building, the teachers demonstrate agency and ownership over their own teaching practice, dedicated to advancing their professional understanding, experimenting with new classroom designs, and going beyond best practice. A major theme emerging from the teachers' reflections on the improvements they had made in their practice is their dedicated, continual efforts for improvement—a central feature that characterizes this ever learning and innovating professional community.

> *I think that my understanding of the [knowledge building] principles completely is different today than it was my first year, and even it is different than a year or two ago. … You're constantly going deeper in what this means... This is a process you need to go, and it never stops.* (A Grade 5/6 teacher commenting his improvements of teaching in the interview)

> *I think as a teacher I've always been … very flexible... I never try to think that worked really well, I'm going to do the same thing again. I always look for ways to improve my practice. I think what the knowledge building process brought to me was making that more explicit, and was embedding it in an environment where it was so embraced.* (A Kindergarten teacher commenting on her role as a teacher in the interview)

The teachers' trust in students' potentials and ownership over their teaching practice help them develop new visions—visions of possibilities not yet fully discernible in education (Bereiter, 2002), which drive them to continually improve their practice. Building such new visions of teaching and learning among teachers is fundamental to the success of education reforms. As Darling-Hammond and McLaughlin (1995) argued, teachers need to rethink their own practice, to construct new classroom roles and expectations about student outcomes, and to teach in ways they have never taught before. Among the ICS teachers, this process of new vision building triggers their needs to

access and conduct research on learning and teaching, which plays an important role in developing and fulfilling their visions.

**A Hybrid Identity That Integrates Teaching and Research**

As the data analyses indicate, the teachers, as well as the Principal, develop a hybrid identity that integrates teaching practice and research. Developing such a hybrid identity and culture among teachers is critical for education to become a research-based, progressive profession that embraces innovation (Bereiter, 2002). While their primary focus is on teaching practice, all the teachers in this study underline the importance of having a researcher's mind and eyes and integrating research elements in teaching. They experiment with new designs in classroom, and sometimes, initiate their research studies focusing on certain aspect of their teaching. They collect data to examine how their changes affect the students[1], and reflect on their pedagogical ideas and designs. They read research literature and interact with researchers to access and develop new ideas, and present their work at conferences. Their engagement in the knowledge building innovation makes these efforts much more purposeful, intensive, and collaborative.

> *In practice, in a way as a teacher, we should always have a mind of researcher. Even if we are not sharing research in any kind of formal way, as a teacher growing with the children, you always need to be wondering about what's happening and asking yourself questions and testing things out, and looking for feedback from your kids. What can you observe is what you are doing is making a difference.* (A Grade 2 teacher commenting on her role as a teacher in the interview)

The Principal sees research as central to the mission of the school. She supports teachers' involvements in and connections with research by releasing time, creating professional development meetings, providing professional development money, and building relationships with research/professional organizations.

> *We spend a lot of time on research. In our staff meetings we set aside a good amount of time and enshrine that to spend time on research: outside and inside. We allow teachers to go places to present research, to bring in outside research, and our PD*

[1] Knowledge Forum provides a set of automated analytic tools to help teachers obtain feedback data, including contribution rate, vocabulary use, semantic growth, and social networks of online interactions. This appears to be especially helpful for the teachers' improvement.

*(professional development) is around evidence. We are in a research mode of thinking. Those are strong factors of who we are.* (The Principal commenting on the role of the teachers in the interview)

**Deepening Pedagogical Understanding, Evolving Designs, and Addressing Deeper Challenges**

The teachers started their knowledge building practice with understanding the knowledge building principles, as described in writing materials and presented by researchers and teachers. There are no standard "how to" procedures provided to teachers regarding the implementation of the principles. Effective knowledge building designs and implementations depend on teacher innovativeness in daily practice. The teachers often focus on several of the 12 knowledge building principles in a particular year, and try to achieve a deeper understanding of the principles as they develop, test, and reflect on their learning designs in specific classroom contexts and content areas. They conduct weekly meetings to discuss the knowledge building principles, share their designs and practices, and identify challenges and opportunities, with the goal of exchanging insights and continually advancing practice instead of ritualizing their classroom procedures.

For example, one of the knowledge building principles is "knowledge building discourse," which refers to discursive practice that results in not only the sharing of knowledge, but also the refinement and transformation of knowledge and emergence of new ideas (Scardamalia, 2002). Knowledge Forum supports knowledge building discourse in an online environment that is a continuation and enrichment of classroom conversations. To engage students in knowledge building discourse in classroom, teachers at the school developed a design called "Knowledge Building Talk" ("KB Talk"). The original design of a Knowledge Building Talk is to have students sit in a circle, with the teacher as an equal member of the group. Their conversations focus on problems of understanding and knowledge advances, with the goal of collectively seeking deeper understanding in a domain (see Reeve, 2001). This approach has been subsequently adopted by many teachers in the school. Data analyses showed that the teachers do not merely replicate the activity structures of their peers, but have evolved different design strategies to engage knowledge building discourse in different classroom contexts, and conduct KB talk in a more flexible, spontaneous, and productive way. Below are two teachers' reflections on their improvements to Knowledge Building Talks:

*We would hear what the principle was, [knowledge building discourse]. We would go into the classrooms, and we would do it differently. And then we would come back*

*and talk about it… When I first started, KB talk was on the schedule. They were every Tuesday 10 o'clock. I realized that wasn't working, because sometimes we had that time and we had nothing to talk about. Then we developed a sort of... We have pockets on the board, and if you have something to talk about, you would write it on a piece of paper…They would put the paper there, and I would pull them out, read it out, or pass it to that person. That was better, but still a bit too prescriptive. What's happening now… is I don't necessarily plan a KB talk. But they become more spontaneous. KB talks always used to be sitting down in a circle; that is not the case any more. It could be in the classroom, someone sits in the chair, someone sits on the floor, as long as everyone is following… Much less structured, more organic, spontaneous. They also can vary. I mean, we are not trying to filling up 30 minutes. If takes 10 minutes, that's it. If it takes 40 minutes, that's fine too.* (A Grade 5/6 teacher reflecting on his improvements to KB Talk in the interview)

*I played around with it (KB Talk) a lot, because I'm really interested in discourse, and in trying to have children talk to each other without putting their hands up, so that if their ideas build on to someone else's, they can just say it. So I over the years was trying to get one person start and the children just talk. They take turns and don't put their hands up. They learn to hold back. If someone else starts to talk at the same time, they need to wait. It's very hard for kids, but I like the discussion that feels more like a conversation, not like the teacher choosing as the children put their hands up. So that's been a big thing for me. (*A Grade 3 teacher reflecting on her improvements to KB Talk in the interview)

The teachers are responsible for the initiation of the designs of Knowledge Building Talks, and maintain intentional efforts to experiment with new design features to enable more productive, authentic, and collectively engaged knowledge building processes.

An important, intrinsic force driving the teachers' efforts to evolve new designs is their sensitivity to emergent challenges and problems facing their knowledge building practice. Instead of avoiding problems, they intentionally identify deeper problems that need to be addressed in specific contexts, thereby discern new areas that need improvement and experimentation.

*It is always a challenge when confronted with what to do when there is a student who already has the "right" information and is, therefore, considered the authority by the group. KB (knowledge building) can quickly come to a halt when that*

*happens.* (A Pre-K teacher commenting on her classroom challenges in the interview)

*There are so many questions; we need to be able to focus on the ones so that we can go deeper with the knowledge rather than staying on the surface.* (A Grade 2 teacher commenting on her classroom challenges in the interview)

**Collaborative Emergence: Collective Responsibility over Knowledge Building Processes**

Working with a set of principles (Scardamalia, 2002) instead of pre-specified procedures, the teachers perceive great opportunities and demands to make flexible, responsive decisions during classroom interactions, with planned activities adjusted and new strategies generated and adopted in an emergent way. The knowledge building processes are characteristic of what Sawyer (2004) called "collaborative emergence"—or "collaborative improvisation"—in which the outcome cannot be fully predicted or specified in advance, and the process is collectively determined by all participants instead of a single, authoritative member. With the increase of collaborative emergence comes a higher level of symmetry in classroom interactions (Tabak & Baumgartner, 2004), with both the teacher and students being able to contribute to the flow of their conversations, so that students can take on higher-level responsibility in deciding what and how to learn. Students contribute their diverse ideas in the community, which drive the process of their collaborative knowledge building.

*... It was the very first day of school, I thought it would be interesting to do a study of trees. ... And I tried to think where it might go. So I can imagine, every year, five-year-olds bring leaves to class. Every year in the fall, they bring in different colors of leaves, they look at the shapes...I think I would probably be talking about leaves and colors and maybe get to the cells. I didn't have gone beyond that... So the very first day, I started asking kids what they knew about trees. And as they told me about different parts of trees, I drew on a piece of chart paper. So someone said branches...twigs...and then a child said: "lungs." And I just stopped… It's such a clear way that puts me in an interesting position. So I said: "Where would I put the lungs?" And she said: "I don't know. They have to breath, don't they? They're alive." And for the next months, we looked into how trees breathe. That's how it caught children's interests in the class. I knew nothing about it... It was absolutely*

> *fascinating!... And it was amazing to notice that you don't have to have these arbitrary barriers, that you can study so many things: do literacy and drama, and deep thinking, and specific experiments...every kinds of learning we want the children to do, you can actually do as one topic, because if it's a good topic, like trees and breathe, it is so rich, there're so many directions you can go. It led them to the human body, because they were thinking about breathing...So for me it was a huge moment as a teacher to realize just how much you can blast open the possibilities of depth and time.* (A Kindergarten teacher reflecting on her advances in teaching in the interview)

A related interesting phenomenon observed in the classrooms is that learning design strategies are often co-constructed by teachers and students through an interactive process. Students and their teacher collaboratively decide on what views (work spaces) should be created in Knowledge Forum, how they should be linked, and how students should be grouped. They discuss issues such as: what are the weak areas that need deeper research? what experiments need to be conducted to test our theories? when do we need a Knowledge Building Talk and what should it focus on?, and so forth. The collective wisdom of the whole community contributes to the evolution of the knowledge building designs, strategies, and processes, making the knowledge building practice an ever-improving endeavor.

Embracing emergence and improvisation in teaching requires the teachers to re-conceptualize their role and control in classroom. The teacher needs to keep things under control in classroom. Using the word of a teacher in this study, he/she needs to "hold the pieces together." But this does not means that he/she needs to control each individual in terms of when to do what in what ways and put the class into a pre-specified structure. When planning and facilitating knowledge building classes, the teachers in this study identify big ideas and important problems in a content domain, think about possible connections with related areas, leave the processes open, and enhance the collective responsibility of the community for the evolution of their knowledge building goals and processes. The curriculum becomes a progressive, unfolding process that is driven by student thinking and conversations.

The teachers seem to have gradually embraced greater emergence and improvisation in their practice. Their comfort level increases as a result of their trust in student agency and the belief that a student-driven, open-ended, collectively engaged inquiry process can really work out.

*The other thing … is the control that as a teacher, when you're early in your career, you want…the principal to come to your room, and you're able to say: "Everybody is writing that right now." You know, that's safe. Knowledge building is not like that. So in order to feel like I knew what everybody is doing … I spent a lot of time saying: What you're going to be doing, what you're going to be doing, OK, go, come back, tell me what you did. I still do a little bit of that. But it took a lot of time to do that, and was still very structured, and there wasn't enough fluidity. So I learned to really have to face what students do. … So the students thought they were reading an article about something, then new question appeared. They could actually go and do something else. So as a teacher I have to learn that it's OK to say: "I'm not sure what that group is doing." I can go and find out and ask them. I know that they were able to answer it. The children might work inside, outside, in the hallway. That's fine, because when they come back, I realize students are usually on task, and they are able to go deeply, because they have been given the opportunity to do that*. (A Grade 5/6 teacher reflecting on his advances of teaching in the interview)

**Enacting Innovation in a Complex Reality**

Teachers work in a complex reality, interacting with many students at once, juggling multiple goals that often require trade-offs from moment to moment (Hammerness et al., 2005; Jackson, 1974). A big challenge facing the teachers in the present study is to maintain a focus on teaching innovation while dealing with multiple, changing demands in school that all require time investments. Central to the philosophy of the school is a dedication to "education for all," aiming to understand and respond to the needs of individual students and promote their development in all aspects, social, cognitive, emotional, and physical. The teachers try to connect these missions to the creation of a knowledge building community where students respect, care, and listen to each other's ideas and feelings, and make reflective and fair decisions, and take collective responsibility in their work, with every student being an active, contributive member. Dealing with behavioral problems becomes a part of their efforts to create an accepting, caring, and responsible community that can collaboratively build and share knowledge.

*This year, I'm finding that I have social issues that I have not encountered with this group of four…They came in with a culture where certain voices had absolute authority over other children. If they said something, the other children, even they are upset about it, would accept it... So that has been really a big focus for me and making sure that when we're in a group, children who used to be followers…know*

*that I value their voice as much as I value what other child has to say. And maybe in that moment, I value theirs more, because it's new for them to speak out and it's new for others to hear it. So I work so hard to make those voices heard...For children who used to be top dogs they feel a little bit threatened… I need to find ways to make them feel safe and successful without have their thumbs on other children…* (A Kindergarten teacher commenting on her classroom challenges in the interview)

Adding to the complexity and messiness of classroom life are problems associated with technology use. In most of the classrooms, there are no one-to-one computing facilities. Teachers need to come up with a responsive, flexible schedule so that students can access computers when they have a real need, and provide necessary support to help all student contribute to and benefit from the online knowledge space. For example, in her first year with the knowledge building pedagogy, Teacher Z worked with a Grade 2 class. According to her reflection journal (Calendar of Inquiry), a challenge she encountered was that the second-graders were not comfortable typing, so they could not enter their ideas into Knowledge Forum's communal space so others could build on and improve them. After talking to her colleagues at a meeting, she decided to address this challenge using several strategies:

*Children who want to will type their notes themselves. When children are on the database, adults [the teacher and her intern] may come and offer to take over the typing for a period of time or to help them to finish off their note if time is running out or if the child seems to be tiring. Children may request that an adult type the entire note for them. Children may write the note by hand and have an adult enter it into the database as the child reads it aloud.*

After testing these strategies in her classroom, the teacher wrote in her Calendar of Inquiry:

*I think that giving them choices … does provide a way in for everyone and that not insisting that they type for themselves takes typing out the equation and puts ideas at the centre.*

There are moments when some computers cannot connect to the Internet, a student forgets his/her password, or other technical problems occur. Although there are a number of ways for the teachers to obtain technical support; instant, on-site technological support

is not available at this point. The teachers need to develop alternative, flexible strategies to make sure that students can proceed with their ongoing knowledge building work.

> *The other challenge is always technology, and how it is unreliable. And this morning when we tried to use it, someone's laptop doesn't work, some other's laptop doesn't connect to the Internet, and you know, new things about [Knowledge Forum] 4.6… My intern today said...like everybody was on, and leaving about three or four students, and he said: "...we're having problems with technology." … And I have to sort of look at him and say: "No, actually, everything is working, and we're going to fix those..." It puts you in a role where you have to be happy all the time about technology. That's a lot of work. Because children are watching you, and you can give up easily… So we always need to be flexible.* (A Grade 5/6 teacher commenting on his classroom challenges)

Another practical constraint the teachers need to work with is time. They have to spend time on different tasks/needs, for example, dealing with unexpected events, talking to parents, organizing field trips, etc., and also need to find a proper balance between teaching and personal life. For example, the librarian of the school has been working with students from different grades to develop reading and information-seeking skills, often focusing on topics the students are studying in their classrooms. Responding to the interview question on what challenges she was facing, she said:

> *Time is always a challenge. Sometimes if I have to do certain things the time I have with them is only 20 minutes. That is the reason for setting up the independent system for checking out the books so that it doesn't take up my time, so that I end up with more time to do the teaching.*

In a similar way, the teacher, who has been working on integrating knowledge building in physical education in cooperation with content teachers, commented on his challenges in the interview:

> *Our schedules are very busy and can be disjointed. For the kind of deep understanding we are trying to develop, it requires blocks of time, even though it is difficult. It is something we all need to work on together.*

**Collegial Support, Professional Knowledge Building Discourse**

On a regular basis (usually every Thursday), the teachers meet to talk about their problems of understanding and knowledge advances; and share their plans, actions, observations, reflection, and problems, and discuss technological issues they have encountered (See Appendix 3 for a section of the minutes taken at a meeting). These meetings are recorded and indexed, and the records are uploaded to a website to facilitate subsequent review and reflection and sharing with broader communities. Each teacher maintains a reflection journal, called "Calendar of Inquiry (COI)," in Knowledge Forum, which is accessible to colleagues and researchers. Additionally, they find partners to work together to explore possibilities of cross-disciplinary, cross-classroom knowledge building initiatives (e.g., a grade 5/6 teacher collaborated with the physical education teacher to facilitate inquiry of human body), experiment with new design ideas, and address common challenges they are facing. Their sharing, conversation, and collaboration help weave together their individual efforts for innovation and improvement, and substantially increase the collective, innovative capacity of this teacher community.

> *There are always people here you can go to. There are so many ideas, so much experience. There is so much willingness and enthusiasm to follow something through. Anytime I have an idea, a question and I want to connect with another class or another teacher, you pretty much have people who are willing to go ahead and do it.* (A Kindergarten teacher commenting on collegial support in the interview)

> *Doors are always open, never made me feel as if I were imposing. I have more questions now than ever...* (A Grade 4 teacher commenting on collegial support in the interview)

> *I have adopted many of the innovations of my colleagues by adapting them to suit my classroom… The KF meetings on Thursday afternoons provide me with an opportunity to share my ideas and get feedback…* (A Pre-K teacher commenting on collegial support in the interview)

At the meetings, the teachers not only talk about practical classroom issues and experiences, but also problems of understanding related to deep pedagogical issues. They intentionally rise above the classroom cases (e.g., activity designs, processes, tools) shared by different teachers to achieve principle-based understandings of specific

knowledge building designs and processes, so that these designs can be adapted to different contexts.

> *I think the notion of how you do it, step A, B, C, D, is not what we can pass on. You can't decide what goes next. But the idea that there are tools that you as a designer can use and that you need to learn the tool, can use to help you do it is what we could do. So to do a how-to of doing a KB Talk – about how to use the software, about how you facilitate the kids, how to ask questions, those are pieces we can give. When you pick up the pieces, how to order those pieces? ...We have philosophy.* (A Grade 5/6 teacher commenting what is sharable in practice at a Thursday meeting)

The school creates a safe and supportive environment where teachers are encouraged to expose their problems, seek deeper understanding of the knowledge building principles, experiment with new ideas and designs, and sustain collegial dialogue and critical reflection. In the weekly meetings, the teachers have open, productive conversations focusing advances they have made and problems they are facing. Instead of trying to eliminate problems and ritualize their classroom practice, they accept problems and their emergence in new forms as a norm of their practice, with dedication to levels of productive disequilibrium (Wilson & Berne, 1999) that helps them to continually learn new things, achieve new insights, and improve their practice each year. The important themes observed in individual teachers—deep trust in student agency and ownership over practice, a hybrid identity connecting practice with research, continually deepening pedagogical understanding and evolving designs, embracing collaborative emergence—are all evident too at the community level, through their daily talks, regular meetings and professional development events, and collaborations in teaching.

> *The notion of improvable ideas fits perfectly with the sense that we are always going to be improving our practice. We encourage dialogue amongst the teachers and how they solve their own problems… We assume there will be problems of understanding. You are not the best teacher if you don't have a problem of understanding. We are inviting you to share those problems and come together on how to solve them*. (The Principal commenting on her ways to support the teachers' innovation efforts in the interview)

> *… Everybody here is so interested in their teaching and improving it. And people will talk about things that didn't go well. There's not a sort of pretending that everything*

*is great. You know, people bring their problems up, and they admit when things aren't going well and ask each other for help. So that makes it so easy to do that myself.* (A Grade 3 teacher commenting on colleagues' support in the interview)

*I often will reflect on what the stumbling blocks are, talk to colleagues, reflect on their views, work again in the classroom, and then attempt to move forward with new ideas.* (A Grade 1 teacher commenting on colleagues' support in the interview)

*You'll hear on the Thursday afternoons. None of us says: "This is the way you need to do it." What we might say is: "B did it this way, Z did it this way, and I've done this way. How do you think you're going to do it? Please let us know because it may be a totally different, a better way of doing something." So none of us has learned it. We're all learners. That's a difference. Once you think you know, you'll die I think. I want to live. [Laugh]* (A Grade 5/6 teacher commenting on colleagues' support in the interview)

The rich, open conversations and sharing in this professional community provide apprenticeship support for new teachers as they get started and move forward with knowledge building. They can observe knowledge building processes taking place in different grades and content areas, understand the richness and complexity of authentic classroom problems (Putnam & Borko, 2000), access diverse design strategies and implicit expertise of experienced teachers, and receive feedback from them. The example provided in Appendix 3 shows a new knowledge building teacher, N, sharing her problems at the meeting and receiving suggestions from colleagues. But exposing problems is not limited to new teachers; experienced teachers often do the same at the meetings, engaging both new and experienced teachers in deep discussions about the problems.

*Other teachers share information, experiences and challenges and that helps me grow. (*N, the Grade 2 teacher)

*This [meeting weekly] is an opportunity for me to learn about what experienced teachers are doing, to learn from that and to ask questions of them, and to brainstorm solutions.* (A second-year knowledge building teacher teaching physical education.)

*Meeting weekly with teachers who have more experience has been fundamental in keeping me motivated. When I know that I can ask for help if I need it, it becomes easier to try new things alone. The chance to view the COIs [Calendars of Inquiry] of other teachers has also been extremely helpful. This has allowed me to get a sense of what questions teachers are asking themselves as they are growing in their field. (*A second-year knowledge building teacher teaching Grade 1 commenting on collegial support in the interview)

**Create a Dynamic School Environment through Leadership Support**

The responses from the teachers converge at the vital role of the Principal's leadership support in sustaining innovations among the professional community. The interviews with the teachers and the Principal revealed several important aspects of the leadership support. The Principal (a) explicitly underlines the importance of research, collaboration, and innovation across contexts; (b) communicates her high expectations of teaching excellence and innovation, together with her trust, to the teachers, and gives them the flexibility and autonomy to try out new ideas; (c) creates social structures and opportunities for them to share and talk about their ideas and practices, and participates in these meetings to understand the advances and challenges of the teachers; (d) conducts "professionally" oriented conversations with individual teachers regarding classroom practices, student learning, and teacher development, as opposed to "administratively" oriented talks (Chesler, Schmuch, & Lippitt, 1963); (e) provides financial resources and release time to support teachers' professional development (e.g., visiting other classrooms and schools, presenting at conferences); and (f) connects with research and professional organizations and interacts with students' families to obtain external support. These roles focus on creating an autonomous, supportive, stimulating, and collaborative environment, mobilizing collegial interactions and idea contacts, and making external connections.

*When teachers first start here and are shown to the classroom, they are probably wondering: "where are the textbooks?" The way the room looks is like the KF [Knowledge Forum] database at the beginning [it is a free space]. The physical place is not filled up with signs and signals that we have it all figured out here. We have a teacher handbook, but in no way does it talk about how to teach. It talks about the philosophy of the school… They will be designing and creating their year with the children, that innovation is valued here.* (The Principal commenting on her support to teachers' innovation efforts in the interview)

*[The Principal] conveys an implicit trust in us [the teachers]. While she is excited about the kinds of innovation that are taking place in our classrooms, she does not manage the teaching that takes place in them. She sets the stage for teachers to feel secure enough so that our own inquiry can take place*. (A Pre-K teacher commenting on the Principal's support in the interview)

*…I think also that she encourages dialogues among our teachers. She doesn't always hold herself as an expert… But she will say: "speak to so and so. They've done that." And you know, providing meetings where we can do that.* (A Grade 2 teacher commenting on the Principal's support in the interview)

## Discussion

The reported analyses elaborate seven key processes/conditions that inspire, enable, and sustain the knowledge building innovation at ICS. These processes/conditions appear to be deeply connected; any of them cannot be fully actualized without systematic efforts to address related issues. For example, the teachers' deep ownership of teaching practice relies on individual teachers' dedicated efforts for continual improvement; the embracing environment of the professional community that values critical dialogue, risk-taking, and experimentation; as well as the Principal's strong support of teacher autonomy. Similarly, the teachers' embracement of collaborative emergence in classroom is augmented through their deep trust in student agency, their principle-based approach to classroom practice, efforts to continually evolve new design strategies, and the community and school contexts that encourage risk-taking, flexibility, and collaboration in classroom practice.

These interrelated factors represent sustained innovativeness arising from three increasingly nested levels: (a) Individual identity and efforts, which include the teachers' deep trust in student agency and ownership over their practice, their in-taking of research elements in practice, continual efforts to advance pedagogical understanding and designs and break related barriers, increased comfort level with collaborative emergence in classroom, and their dedicated efforts to address changing, multiple demands while focusing on the knowledge building innovation. (b) Dynamic interactions in the teacher community, which involve sustained, professional knowledge building discourse, shared and collaborative pedagogical practice, and rich apprenticeship support. (c) The school contexts—created through strong leadership supports—that embrace and support the

above individual and collective efforts and maintain dynamic interactions with outside professional and research organizations and local communities.

Data analyses suggest that the teachers themselves have incorporated the knowledge building principles, for example, epistemic agency, continual idea improvement, knowledge building discourse, collective responsibility for community knowledge, etc. (Scardamalia, 2002), into their own professional life, and formed a knowledge building community in their own right. This community in many ways resembles what McLaughlin and Talbert (2001) called a "teacher learning community," but with a strong focus on collaborative pedagogical innovation. Teachers are not only implementers of the innovation; they are themselves grass-root innovators (Zhang, 2007; Zhang & Scardamalia, 2007). Developing professional communities of this nature among teachers is fundamental to enabling sustained, deep learning innovation in schools. The specific analyses reported in this article help understand the basic processes and conditions involved in developing such professional communities.

These analyses were generated from a laboratory school that represents a supportive context for deep innovation. However, the seven key processes/conditions that inspire and sustain the knowledge building innovation at ICS appear to be essential across contexts. Collectively, these seven themes characterize a dedicated school community that continually pursues innovation, instead of an all too special case—an elite school—that is unattainable for other schools. The processes and conditions are achievable in non-laboratory schools through dedicated, sustained, and connected efforts. The only factor that is somehow unique to laboratory schools is the strong connections between educational practice and research; but teachers in a general public school can also work with the research-practice continuum by integrating and embedding research elements in their daily practice, for example, experimenting with new design strategies, collecting feedback information, and reflecting on effectiveness of their designs.

## Conclusions

Through analyses of interview data, reflection journals, and field observations, this study investigated how the teachers at an elementary school sustained the knowledge building innovation. Key conducive factors identified included: (a) Shared visions and deep ownership of teaching practice, coupled with deep trust in students' agency and potentials; (b) A hybrid identity that connects teaching with research; (c) Dedicated efforts to deepen pedagogical understanding, evolve designs, and break barriers; (d) Collaborative emergence in classroom practice; (e) Dealing with the complex reality in

classroom while maintaining a focus on innovation and improvement; (f) Professional dialogues and apprenticeship; and (g) Strong leadership support for innovation. Deep analyses of these essential processes and structures can help inform systematic strategies for enabling deep and sustainable learning innovations in schools. Apparently, bringing these processes and conditions into different school contexts would face different challenges. To deepen and triangulate the findings from this study, we are conducting deeper analyses of the data from ICS and collecting new data from a wide spectrum of schools that are implementing the knowledge building pedagogy and technology.

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**Appendix 1.** Teacher Interview Protocol

The purpose of this interview is to understand how teachers at ICS approach and improve their teaching, so that we can identify important factors conducive of innovative teaching.

1. (a) How do you see the role of yourself as a teacher relative to a researcher? (b) How would you answer the same question before you adopted knowledge building practice?
2. (a) What are the three most important qualities you would like to develop in your students? (b) What are the major things you do to develop these qualities?
3. (a) What are the most important efforts you make to enable your class to operate as a community? (b) How would you describe this community?
4. What have been your three most important improvements in your teaching in the past years? Please elaborate when and how these improvements happened.
5. (a) From what sources did you first learn about the approach of Knowledge Building Talk (KB Talk)? (b) In what ways have you improved KB talks in your classroom?
6. (a) What are the major challenging issues you encounter in your classroom recently? (b) How do you respond?
7. In what way do you see your colleagues as supportive of your efforts for seeking innovation in teaching? Please name at least three major aspects.
8. (a) In what way do you see your principal as supportive of your efforts for innovation in teaching? (b) What further support from your school would you need?

**Appendix 2.** Principal Interview Protocol

The purpose of this interview is to understand the school culture of ICS that sustains

teachers' innovative efforts, and your role as the principal in learning and teaching innovation. We have prepared a number of questions for you. Please feel free to tell us things that are important but haven't been covered by these questions.

1. How do you see the role of teachers relative to researchers?
2. (a) What are the three most important qualities you would like to develop in ICS students? (b) In what sense is ICS helping to develop these qualities?
3. (a) What are the three most important qualities you would like to develop in ICS teachers? (b) In what sense is the professional development in ICS helping to develop these qualities?
4. (a) In what ways do you see ICS as supportive of teachers' teaching innovation? (b) What are the top three things you hope to improve?
5. What roles do you play in sustaining the knowledge building innovation at ICS?
6. Suppose that a principal from another school wants to get started with knowledge building, and comes to visit you for advice, what would be your top suggestions for him/her?
7. In what ways does the larger educational system encourage or discourage your innovative efforts at ICS?
8. Are supports from students' parents important for the knowledge building initiative? How do you get their supports?
9. Are there any other things we should know about in understanding the KB culture at ICS?

**Appendix 3.** A section of the minutes taken at a meeting of the teachers.
The minutes have been edited to make it more readable. The conversation began with N, a first-year knowledge building teacher (Grade 2) sharing a problem. Her class raised a couple of rats as class pets, had been conducting inquiry about the rats. N was struggling how to move the inquiry forward. Her colleagues in the meeting asked questions about her practice, tried to understand her situation, and provided suggestions to help her think through the problem.

Minutes: May 18, 2006

…

N (Grade 2 teacher): Lots of time for lots of [Knowledge Forum] notes, about rats and jumping, and rats and water. What do I do next? Originally thought it would be shorter than the water view [a discussion space in Knowledge Forum about water). Something

on the board about the rats. It's become very deep, extended over a number of weeks. Not sure that there're big questions: original -what do we need to know about rats to take care of them? What do I need to tell people who might be afraid of them?
R (Grade 5/6 teacher): Come across any factors about rats? Experiment? Exercise wheel? Augmenting one, without harming the other?
A researcher who has been observing N's class: [A student] talked about an experiment with water. He had read some things in books about rats.
N: Pan of water, put them [rats] near it and watched them…Do we keep having conversations and going on the database, or is there a shift in the activity of what we are doing?
R: Collecting data monitoring weight and food.
N: There is a constant relationship and feedback from the rats. I feel happy as long as the kids feel happy. Perhaps the conversation is valuable as long as they are still interested.
…
Z (Grade 3 teacher): Kids interests wane. Or if not, maybe time to make rise-aboves [reflective synthesis in Knowledge Forum], create a patch of what they actually know...here are the ones we're still thinking about. Half groups even. But kids have to be OK with things being changed.
C (Senior Kindergarten teacher): why did you want to use [Knowledge Forum] to talk about the rats?
N: …A place to gather their thoughts.
C: So then you are responding to it in a different way. Maybe you would respond to all the information, maybe come up with categories. And move the notes and organize them. You weren't using it for big questions; you were using it for something else.
N: List topics discussed in the rat view [a workspace in Knowledge Forum] made by the kids. Problem - laptop Internet was not working today. Sorting and making a rise-above.
…

Table 1. Seven Salient Domains/Themes Identified from Data Analyses.

| Cover term | Major included terms |
|---|---|
| Epistemic agency | Shared visions of teaching |
| | High expectations and deep trust in student agency and potentials |
| | Adjust the teacher' role to release student agency |
| | Deep ownership over their practice, seeking continual improvement |
| A hybrid identity connecting practice and research | Integrate/embed research elements in teaching |
| | Interact with researchers |
| | Read literature |
| | Intentional experimentations of new designs |
| | Initiate "formal" studies on certain aspects of their practice |
| | Attending and presenting at conferences |
| | The Principal underlines and supports research efforts |
| Deepen pedagogical understanding, evolve designs, and address deeper challenges | Continually seek deeper understanding of the knowledge building principles |
| | Develop, improve, and share designs in light of the principles |
| | Sensitivity to emergent problems; progressive problem solving; addressing challenges through personal and collaborative efforts |
| Collaborative emergence in practice | Open-ended, emergent inquiry processes, progressive curriculum |
| | Accept and work with idea diversity, which drive knowledge building processes |
| | Engage collective responsibility of students in co-constructing the knowledge building processes |
| | Re-conceptualize the teacher's role and control; open planning |
| Enacting innovation in a complex reality | Innovate while dealing with multiple, changing demands in school |
| | Deal with behavioral problems through community building |
| | Deal with technological problems with a strong stomach and through flexible arrangements |
| | Deal with the constraint of time and schedule |
| Collegial support and professional knowledge building discourse | Weekly knowledge building meetings in which teachers talk about their advances and challenges |
| | Plan, reflect on, and share knowledge building practice through Calendars of Inquiry (COI)—online reflection journals |
| | Observe each other's classes and collaborate in design experimentations |
| | Critical reflection and dialogues, productive disequilibrium, motivating risk-taking |

| | |
|---|---|
| | Apprenticeship support for new teachers |
| Create a dynamic school environment through leadership support | Underline research, collaboration, and innovation |
| | High expectations of teaching excellence, deep trust in teachers, and providing flexibility to encourage risk-taking |
| | Setup and participate in regular knowledge building meetings, encourage dialogues, sharing, and collaboration |
| | "Professionally" oriented conversations with individual teachers |
| | Release time and provide financial support for teachers' professional development |
| | Connect with research/professional organizations and parent communities |