Knowledge Building: From Foundations to Current Research

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Abstract

This is an exploration of Integrating Technology into the classroom in ways that enhance learning and give students the skills required by the *Knowledge Age*. By investigating the intellectual heritage of Socio-cultural Constructivist learning theories, I explore how *Knowledge Building*, as developed by Scardamalia and Bereiter, has emerged as an alternative paradigm for teaching and learning. The wider field of Computer Supported Collaborative Learning (CSCL) is discussed to establish the role of computers in collaborative learning communities. I describe the technology and mechanisms by which this process occurs. The principles, pedagogy and the barriers to the adoption of Knowledge Building are outlined. *Knowledge Building* is proposed as a way to teach social values and life long learning skills throughout the school curriculum.

Keywords: Knowledge Building, communities of practice, distributed cognition, collaborative learning, enculturation, collective cognitive responsibility

1 Learning Theories: The Intellectual Heritage

The *Theory of Cognitive Development* in children proposed by the Swiss psychologist Jean Piaget (1896-1980) considers learning to be a product of a child's interaction with their environment. Intellectual growth involves taking in new information into existing mental structures called schemas (assimilation), changing existing schemas to account for this new information (accommodation) and bringing the self and reality into balance (equilibration). In an effort to adapt to the environment the child constructs their understanding of the world: a *Constructivist Learning Theory*.

The Soviet psychologist Lev Vygotsky (1896-1934) considered learning to first emerge at a social level between people, later to be internalised by the individual. He stressed the importance of social interaction in the learning process, introducing concepts such as the *Zone of Proximal Development'*(ZPD) and the notion that tools are used to mediate action. The ZPD represents the enhanced capabilities of the child when they work with their mother.

> We propose that the essential feature of learning is that it creates the zone of proximal development; that is, learning awakens a variety of internal developmental processes that are able to operate only when the child is interacting with people in his environment and in cooperation with his peers. Once these processes are internalised, they become part of the child's independent developmental achievement. (Vygotsky, 1978, p. 90. Note: Vygotsky's work was not translated into English until this time.)

Guiding the child through this ZPD can be seen as a form of scaffolding.

Vygotsky's socio-cultural approach is still influential in educational research. Vygotsky provided the initial impetus to the evolution of the *Activity Theory of Learning*. The shift in focus from individual cognitive strategies to a socio-cultural focus can be seen in Ann Brown's work on *reciprocal teaching* (Palincsar & Brown, 1984), and *communities of learners* (Brown & Campione, 1990). Reciprocal teaching is about peers, teachers and students teaching each other.

Jean Lave (1991) continued Vygotsky's line of work to demonstrate the:

> Importance of social interaction, the joint construction of meaning, the distributed character of knowing, and, hence, the partial, transformed, situated nature of that which is taken in. (Lave, 1991, p. 79)

The notions of *legitimate peripheral participation* in a *community of practice* (Lave & Wenger, 1991) became dominating principles of a *Situated Theory of Cognition*.

> We have thus situated learning in the trajectories of participation in which it takes meaning (Lave & Wenger, 1991, p. 121)

No longer could learning be seen as something that happens just within the mind of an individual. The importance of social interactions and the situated nature of experience became well established. These changes in cognitive theories were co-evolving with the introduction of computers into classrooms. In line with Vygotsky's notion that tools are used to mediate action, Lave and Wenger regarded:

> Participation involving technology [as] especially significant because the artefacts used within a cultural practice carry a substantial portion of that practice's heritage. (Lave & Wenger, 1991, p. 101)

Another extension of situated cognition is that of *Distributed Cognition* which can be described as our ability to distribute knowledge and cognition outside our individual minds.

> Distributed cognition refers to a process in which cognitive resources are shared socially in order to extend individual cognitive resources or to accomplish something that an individual agent could not achieve alone. (Lehtinen, 2003, p. 41)

As the World Wide Web developed so too did the possibilities for distributed cognition. A *community of practice* became increasingly relevant to education. The focus of education became one of social engagement designed in such a way "to effectively support individual and collective growth." (Hewitt, 2004, p. 210) Jim Hewitt is a key member of the Knowledge building team working with Scardamalia and Bereiter in Toronto.

1.1 Two Metaphors of Learning

Anne Sfard (1998) described these educational developments of the eighties and nineties as a shift from the *acquisition* of knowledge to *participation* in a community of practice.

> First, they simply talked about passive reception of knowledge, then about its being actively constructed by the learner: later, they analysed the ways in which concepts are transferred from social to an individual plane and internalised by the student; eventually, they envisioned learning as a never ending self-regulating process of emergence in a continuing interaction with peers, teachers and texts. (Sfard, 1998, p. 6)

This "participation metaphor has a potential to lead to a new, more democratic practice of learning and teaching." (Sfard, 1998, p. 9) Carl Bereiter (2002) described the Acquisition metaphor as a *folk theory of knowledge*, a metaphor of mind-as-container, "a structure or scaffold we must struggle to replace, if education is to make headway in the knowledge age". (p.13)

1.2 The Learning Paradox

Sfard discusses a *learning paradox* that forms her argument for the dangers of choosing just one of these metaphors.

> Learning transfer means carrying knowledge across contextual boundaries; therefore, when one refuses to view knowledge as a stand-alone entity and rejects the idea of context as a clearly delineated "area" there is simply nothing to be carried over, and there are no definite boundaries to be crossed. (Sfard, 1998, p. 9)

She argues that learning "is only possible thanks to our ability to transfer existing conceptual schemes into new contexts". (Sfard, 1998, p.10)

How can we transfer knowledge from one situation to another if knowledge is not a stand-alone entity giving us nothing to transfer? How can we construct more complex ideas from simpler ideas and concepts? Bereiter began to look into this 'learning paradox' in 1985. He was influenced by the science philosopher Sir Karl Popper who published "Objective knowledge: An evolutionary approach" in 1972 where he distinguished:

> Three worlds or universes: first, the world of physical objects or of physical states; secondly, the world of states of consciousness, or of mental states, or perhaps of behavioural dispositions to act; and thirdly, the world of objective contents of thought, especially of scientific and poetic thoughts and of works of art. (Popper, 1972, p. 107)

He considered his *third world* to be similar to Plato's Forms or Ideas. His third world included inmates such as problems and problem situations, theories, conjectures, historical accounts, interpretations, proofs, criticisms, and the like (Bereiter, 1997). Most importantly Popper argued for the "independent existence of the third world" (Popper, 1972, p. 107). A concept, theory or idea is something real; a real artefact, a third world object. This gave Bereiter that stand-alone entity that could be transferred across boundaries, the means for the transfer of knowledge. This is how he was able to reconcile this learning paradox. It is an important foundation to Knowledge Building. The independent existence of ideas is essential if the ideas are to provide an object that can always be improved upon.

Bereiter (2002) argues that ideas should be treated as real things out in the world—that there are *conceptual artifacts*, just as there are material artifacts. (p.41) Learning occurs in World 2 while Knowledge building or working with conceptual artifacts concerns World 3. (p. 1-2)

An answer to the question "How can we construct more complex ideas from simpler ideas and concepts?" came when *connectionism* emerged in the late 1980s. Further discussion on this is available in Appendix 1.

I have now described the emergence of the Participation Metaphor of learning, including theories of Cognitive Development, Situated Cognition, Distributed Cognition and Communities of Learners. We have seen how Bereiter resolves the Learning Paradox by adopting Popper's third world of cognitive artefacts.

2 Computer Supported Collaborative Learning (CSCL)

Knowledge Building is just one of the many forms of Computer Supported Collaborative Learning (CSCL). I will now give some background on CSCL before I investigate Knowledge Building any further.

Initially computers were used in classrooms to provide individualised learning but this was criticised for its anti-social nature. By the 1990s CSCL arose with the potential for social interaction made available by computer networks and the Internet (Stahl et al., 2006). CSCL came in many different forms: intra-, inter-, or extra-classroom, presenting or simulating a problem, mediating communication or introducing new resources. Some provide modelling tools "that enable learners to model their shared understanding of new concepts" while others provide archival storage for products of group work, thereby supporting knowledge building. (Koschmann & O'Malley, 1994)

2.1 Collaborative Learning

Collaboration is something quite different from cooperative learning. Cooperative learning usually involves splitting up the work into sub-tasks as a way of sharing the workload of a larger project. These are effectively individual tasks that contribute to a group product. Dillenbourg (1999) argued that *collaboration* and *cooperation* differ not in the division of labour but in the rigidity of this division of labour. If decisions about what each member of the team does are made together by the group, then it is collaboration. The essence of collaboration is working *together* (Dillenbourg, 1999).

> Collaboration involves the mutual engagement of participants in a co-ordinated effort to solve the problem together. (Roschelle & Teasley, 1995, p.70)

Roschelle & Teasley (1995) argue that collaborative problem solving consists of two concurrent activities: solving the problem together and building a *shared conception* of the problem in relation to a j*oint problem space*. They describe computers as a cognitive tool for group discussion and negotiation directed towards the construction of shared meanings and solutions to problems.

Dillenbourg (2002) identified three concurrent processes in collaboration: the communication or interaction process, the organisation or coordination processes and the task level or problem solving processes. The collaborative process depends on all three of these processes working effectively.

> Collaboration is a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem. (Roschelle & Teasley, 1995, p.70)

This view is of collaborative learning as a "negotiated and shared conceptual space constructed through the external mediational framework of shared language, situation and activity" (Roschelle & Teasley, 1995, p.70) will serve us well as we move into our exploration of Knowledge Building.

Jeremy Roschelle (1996) made a deeper analysis of collaboration as *convergence.* Through iterative cycles of displaying, confirming, and repairing meanings, a group of collaborators aim to find one common or 'convergent' understanding. He emphasised the "mutual construction of understanding, democratic participation, intellectual progress, and gradual convergence." (Roschelle, 1996, p. 245) This is sometimes referred to as *collective cognition* or *group cognition* (Stahl, 2006).

Research has found that "collaborative groups facilitate greater cognitive development than the same individuals would achieve when working alone." (Lehtinen, 2003, p.39) This is in line with Vygotsky's Zone of Proximal Development.

2.2 Changes for Teachers and Students

The affordances provided by new technologies in the classroom provide an opportunity to change educational practices, dynamics and attitudes to learning. Collins & Bielaczyc's (1999) description below distils my personal experience of teaching with computers in secondary schools.

> A major shift in classroom culture concerned the roles and power relations introduced by the technology. When students were working on computers, the teacher became less of an authority figure who controlled what happened. Because teachers did not have to control what students were doing, they were free to help those students who needed it the more. Here, students came to see the teacher as a helper and problem solver. In fact, they enjoyed seeing the teacher challenged by problems and puzzling through them with the students. (Collins & Bielaczyc, 1999, p. 134)

In addition to changes in the teacher's role is the potential for cultural change in student attitudes toward risks taking. Working on a computer allows students to "try things out in their own, without the social ramifications of failure" (Collins & Bielaczyc, 1999, p. 134). Attitudes to making mistakes can change as focus is turned toward the development of skills to fix mistakes, in a manner similar to debugging.

Bereiter (1997) identified another process of *enculturation*. He considers the school's roll to be the enculturation of students into World 3. To do this means

showing students that knowledge is not just something that people acquire. Knowledge is also something that "takes on a life of its own". (Bereiter, 1997, P 19) Bereiter also considers it essential for schools to become knowledge-building organizations themselves.

CSCL researchers have a complex challenge because they "attempt to promote the educational use of the new information/communication technology while simultaneously trying to implement new pedagogical and cognitive practices of learning and instruction (Hakkarainen et al, p. 153, cited in Stahl, 2006, p.214).

2.3 Effective Learning Communities

Bielaczyc & Collins (2000) compare three exemplary cases of learning communities with the aim of extracting general principles for the design of learning communities (p.277). The three cases they compare are: Scardamalia and Bereiter's Knowledge-building Classrooms, Brown and Campione's FCL Classrooms and Lamperts Mathematics Classroom. These principles can be found in Appendix 2.

We have established the socio-cultural nature of learning as participation in learning communities. Working effectively together in collaborative teams requires a process of enculturation. The shift from learning by acquiring knowledge to learning by participating in collaborative teams has been facilitated by the advancements in computer learning environments. It is in this context that Bereiter and Scardamalia began to develop their unique form of CSCL known as Knowledge Building.

3 Knowledge Building

In the late seventies Marlene Scardamalia and Carl Bereiter in Toronto began investigating ways to give children more active roles in school learning. In the early eighties they began to develop the idea of collaborative Knowledge Building with computer support. They had established that children were capable of constructing their own questions to guide inquiry. (Scardamalia & Bereiter, 1991, p.38) They developed a knowledge-based model that focused on developing understanding and turning high-level thought processes, (normally done by the teacher) over to the students. These included helping the student to formulate their own goals, asking their own questions, directing their own inquiry and monitoring their own progress. The application of reciprocal teaching was essential to this model.

As previously discussed, Bereiter (1985) argued for the independent existence of knowledge as objects, for ideas to be treated as cultural artefacts. Technology provided the facilitative infrastructure to direct the community's efforts "toward social processes aimed at improving these objects" (Scardamalia & Bereiter, 1996, p. 254). A knowledge-building environment enables these ideas to "get out into the world and onto a path of continual improvement" (Scardamalia, & Bereiter, 2003. p.1371)

Scardamalia & Bereiter (2003) define Knowledge Building as "the production and continual improvement of ideas of value to a community" (p.1370). It is based on the premise that although the level of achievement may differ, knowledge building is the

same regardless of age or ability. "The goal is to advance the frontiers of knowledge as they perceive them." (Scardamalia & Bereiter, 2003, p.1371)

3.1 CSILE and Knowledge Forum

Implemented in 1983, the Computer Supported Intentional Learning Environment (CSILE) was one of three projects to explore the use of technology to improve learning related to literacy (Stahl et al., 2006, p.4). These three projects shared the goal of making instruction more oriented toward meaning making, introduced novel forms of organised social activity within instruction and laid the groundwork for the emergence of CSCL. (Stahl et al., 2006, p.4)

CSILE came from three lines of research: intentional learning, the process of expertise and restructuring schools as knowledge building communities. The term *intentional learners* refers to students who respond to learning difficulties as problems to be solved in the attainment of cognitive goals as distinct from the completion of a task. (Bereiter & Scardamalia, 1989) Studies suggested that the intentional learner is also able to diagnose their own learning needs and to identify next steps. (Scardamalia & Bereiter, 1992, p.262) Shell et al (1996) found that "a lack of intentional learning strategies and inability to self-initiate and self-regulate ones own learning, was the strongest predictor in a negative manner, of grades." (P.10)

In CSILE, student work took the form of *notes* and *comments* stored in a communal database on the server that was accessible to everyone in the network. The students entered their ideas into a communal space where they could read and reflect on each other's entries (Scardamalia, 2002, p.5). These became the *conceptual artefacts* and *shared intellectual property*. The technology supported sustained collaborative knowledge work (Scardamalia & Bereiter, 2003, p.1372).

The second-generation technology called *Knowledge Forum* has enhanced knowledge-building supports. It too was designed as a workspace for idea improvement with the added benefits of a multimedia database. Features of Knowledge Forum include scaffolding supports for idea development, graphical means for viewing and reconstructing ideas from multiple perspectives, means of joining discourses across communities and other collaborative functions. (Scardamalia & Bereiter, 2003)

Student notes are required to be associated in an epistemological scaffold e.g., My theory, I need to Understand, Comment, New Information, and What We Have Learned. This helps students to systematically interconnect their ideas so that "one idea subsumes, contradicts, constrains, or otherwise relates to a number of others. To gain understanding is to explore these interconnections, and to drill deeper while rising-above, to gain broader perspective." (Scardamalia, 2002, p.6-7)

In addition to the notes and interconnections students can use *views*, graphical representations of their "best collective understanding" (Hewitt, 2004, p. 223). A Discussion Window is now available for the display of many notes at once. Hewitt (2004) found that this allows for more responses to other people's notes, lengthier discussion, more time on task and emphasised communal discourse over individual productions.

> Knowledge forum turns theories, questions, and findings into screen objects that can be pointed at, organised, and talked about. (Hewitt, 2004, p. 220)

This clearly fulfils Bereiter's initial intention, to give knowledge independent existence as an object.

> Knowledge Forum not only mediated the Subject's work on the Object, but it also reinforced the communal nature of the students' research endeavour and the established language protocols of the classroom. (Hewitt, 2004, p. 230)

Knowledge Forum allows students to take control of their own goals, strategies, resources, evaluation. Scardamalia & Bereiter (in press) refer to this as *epistemic agency*. This is in line with their intention to give students a more active role in higher order decisions. Research done by Shell et al. (1996) suggested that this does not mean a diminishing the role of the teacher (p. 9). It is simply a changed role.

3.2 Learning how to Learn

Bereiter (1997) stresses how important it is for all students to *learn how to learn* (p. 10) This means developing "skills such as flexibility, creativity, lifelong love of learning, cooperativeness, and information-finding skills."(Bereiter, 1997.p. 7) Engaging students in sustained and progressive problem solving that requires them to research, construct explanations, criticise, draw out inferences, find applications, talk about the process and thoughts going on etc., is a way to encourage students to develop higher level thinking skills.

3.3 Collective Cognitive Responsibility

Teachers habitually take on sole responsibility for the learning process in their classroom (Scardamalia, 2002). A Knowledge building approach encourages students to take on increasing responsibility for their individual achievement and "share responsibility for community knowledge". (Scardamalia, 2002, p. 7) This is a "shared responsibility for success of the whole knowledge building effort". (Bereiter, 2003) Scardamalia (2002) refers to this as *collective cognitive responsibility*.

> The teacher's role…is largely that of helping students shoulder their responsibilities and advancing knowledge along with them. (Scardamalia, 2002, p. 21)

3.4 An Idea-centered approach

Fostering collective cognitive responsibility requires an idea-centered approach to education. The technology enables this distributed cognitive responsibility by facilitating the student's creation of shared intellectual resources (Scardamalia, 2002, p. 9) that are focused on ideas. In a knowledge-building classroom, students generate their own questions to which they direct their inquiry. The goal shifts from the completion of tasks to the "continual improvement of these ideas" (Scardamalia, 2002, p.9) All good ideas are treated as potentially improvable. (Scardamalia, 2003)

> In a regular class, questions, theories, ideas, and discussions are personal, ethereal constructs. In a KBC classroom, they are public artefacts that have a permanent presence in the classroom database. As such, they can be analysed,

> pointed at, talked about, and progressively refined over time. (Hewitt, 2004, p. 235-236)

Technology also assists students by reducing the *cognitive processing load*, allowing them to consider more complicated problems. Hence technology is meant to facilitate students in managing the requirements of complex tasks (Lehtinen, 2003).

The key to successful collaborative Knowledge Building is *sustained progressive problem solving.* Progressive problem solving involves "continually enlarging the problem space as one becomes able to handle more elements." (Bereiter, 2002, p. 355) Hakkarainen et al. (2002) describe the subtasks of progressive inquiry (refer to Appendix 3).

3.5 Systemic Change

Working together in collaborative communities highlights the importance of the climate or culture in the classroom (Scardamalia et al., 1992, p. 37). Students need to abandon their competitive urges if they are to feel the sense of community needed to work collaboratively. This sense of community can be achieved by fostering trust and respect in the classroom (Hewitt, 2004). I add that one also needs to adopt complimentary assessment policies.

Traditional education is based on an underlying belief "that learning follows naturally from carrying out learning activities and completing tasks" (Scardamalia, 2002, p. 3) To establish a Knowledge Building classroom, the focus needs to shift away from these activities and tasks to a focus on student generated questions and ideas. (Scardamalia, 2002) Students need to see their main job as "producing and improving cognitive artefacts" (Scardamalia and Bereiter, 1996, p.254) Teachers need to set assignments that are open-ended, allowing for diversity of interest and ability.

Schools generally teach cognitive skills and formal knowledge. If they are to support knowledge building they need to be restructured, in particular they need to be supportive of progressive problem solving. (Scardamalia & Bereiter, 1996, p.251)

> Maintaining a school environment in which students feel safe in questioning beliefs, changing their minds, demanding evidence, and trying things beyond the comfort zone of their competence is justifiable on other grounds and may possibly help in developing lifelong thinking dispositions.
> (Bereiter, 2002, p. 365)

If Knowledge Building is to be effective, systemic change is needed to provide a "culture in which the creation and improvement of ideas pervades social life - a process of enculturation." (Scardamalia, 2002, p.24)

3.6 Barriers to Adoption

Scardamalia (2002) discusses three barriers to the adoption of Knowledge Building. Firstly, many teachers do not believe students are capable of it. "At the deepest level, knowledge building can only succeed if teachers believe students are capable of it" (Scardamalia & Bereiter, in press). Secondly they are concerned that students might learn something wrong. To the contrary, Knowledge Building often reveals student's misconceptions. Research by Shell et al. (1996) reported that a knowledge-building

approach to learning appears to facilitate higher achievement even on traditional measures. Thirdly, the belief that students must 'learn first then produce later' (Scardamalia 2002. p.23) is the antithesis to asking questions first then learning from answering those questions.

Oshima et al., (2006) used a Web version of Knowledge Forum called *Web Knowledge Forum*. It has a hyperlink structure and the views are different from Knowledge Forum. This study found that students experienced a tension between the drive to complete tasks and the goal of building community knowledge.

The pervading culture in schools is "extremely resistant to change" (Elmore, 1996), innovative instructional approaches are constantly at risk of being routinised or subsumed into familiar, comfortable categories." (Hewitt, 2004, p. 213)

3.7 Knowledge Building Pedagogy

Scardamalia and Bereiter (1993) described a classroom-based Knowledge Building Community (refer to Appendix 4). Scardamalia (2002) listed twelve socio-cognitive and Technological Determinants of Knowledge Building (refer to Appendix 5).

Jim Hewitt (2004) conducted three years of research on an exemplary knowledge-building teacher. I have listed the characteristics of these successful classes as he describes them (refer to Appendix 6). I consider his most interesting finding to be that "the students' sense of mutual trust, their priorities, and their tolerance for each others' ideas were largely forged through face-to-face processes" (Hewitt, 2004, p. 230) and the "teacher forged this culture of mutual trust and respect in his day-to-day classroom interactions with students." (Hewitt, 2004, p. 233)

Members of the Hong Kong Knowledge Building team, Jan van Aalst, John Kamimura and Carol K.K. Chan, (2005) explored an assessment strategy designed to capture collective as well as individual aspects of knowledge building. They introduced collaborative, co-authored, summary notes as a prototypical assessment strategy. Carol Chan, Eddy Lee and Jan van Aalst (2005, 2006), investigated the introduction of a *portfolio* and the student use of Knowledge Building principles. Developing their prototypical assessment strategy in this study, the portfolio is a *rise-above note* made by the whole group which records knowledge-building events. The portfolio was designed to highlight both individual and community advances. It requires the students to assess their own and the community's knowledge advances. The knowledge-building principles they used were adapted from the twelve proposed by Scardamalia (2002) to make them more accessible to middle-school students (refer to Appendix 7).

Lee et al. (2006) propose "when students are provided with the principles, they can become more aware of what productive discourse entails; the principles are scaffolds for their knowledge-building progressive inquiry." (p. 9) They found that the portfolio "contributed to students' conceptual understanding" (p.301) and "mediated the interaction between individual and collective knowledge advances" (p.305). They also found that students provided with knowledge-building principles participated more and engaged in deeper enquiry than their counterparts who did not have the KB Principles.

3.8 A Third Metaphor of Learning

As early as 1996, Scardamalia and Bereiter considered Knowledge Building to be a *third way* (the first being a didactic approach and the second being an activity centered approach). They considered this third way to be one where the child's curiosity would guide their activities; a *child-centered* approach. In 2002, Hakkarainen et al. proposed that "knowledge creation should be added to the two metaphors" (Cited in Lehtinen, 2003, p.3). More recently Paavola, Lipponen & Hakkarainen (2004) discuss three metaphors of learning. To the acquisition and participating metaphors (Sfard, 1998), they added a third metaphor, the *Knowledge Creation Metaphor*.

In the tradition of comparing methods to illuminate common characteristics, guidelines and general principles of CSCL systems (O'Malley 1995, Bielaczyc & Collins 2000) Paavola et al., (2004) investigated three different models of knowledge creation: Nonaka and Takeuchi's model of Knowledge Creation, Engestrom Cultural-Historical Activity Theory (CHAT) and Bereiter and Scardamalia's Knowledge Forum. Their purpose was to find the commonalities of the three approaches. They listed the characteristics of the Knowledge Creation metaphor (refer to Appendix 8).

4 Concluding Comments

Scardamalia & Bereiter (2003) see knowledge building as "especially promising as the foundation for education in the knowledge age." (p.1327) They propose that this method of teaching gives more than just a strong base in knowledge building. Immersion in a collaborative process is a way to teach "soft skills such as communication, thinking, human-relations and so on." (Bereiter and Scardamalia, 2003, p. 55) Collaborative learning has the potential to teach students social values such as respect, tolerance, social responsibility, caring for others in the team, helping each other and asking for help. It is a way to bring social values, as distinct from religious values, into schools. Knowledge Building is in fact a "deliberate effort to increase the cultural capital." (Scardamalia, 2003)

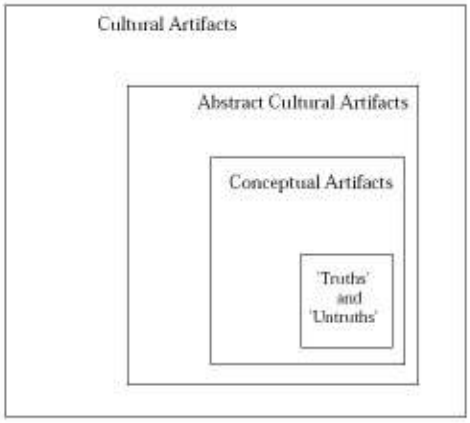
A belief that all ideas are improvable is a lifelong learning skill. One does not get to a point and stop learning, for ideas can always be improved. This makes it worth listening to the views of others because they may help us to improve our ideas. This promotes the value of respecting the ideas of others (Bereiter & Scardamalia, 2003). Paavola et al., (2004) suggest that students can also learn to "consider themselves to be not only consumers but also creators of knowledge."(p. 572) As the creators and contributors to the community's knowledge artifacts I suggest that one can also learn to value oneself.

Contributions to Scardamalia and Bereiter's conception of Knowledge Building have been made by many people, from philosophers such as Plato and Popper, psychologists such as Piaget and Vygotsky and the whole community of researchers in CSCL. It has been a sustained and progressive problem solving process towards giving students a more active role in their learning. This process has produced a collective cognitive artifact, Knowledge Building. It is continually evolving and being improved. Knowledge building can be seen as a World 3 object. It is an idea, theory or pedagogy that can be mediated by technology or treated as an educational philosophy.

By teaching students to be active participants in the creation of knowledge, a Knowledge Building approach to education is a way to help develop life-long skill for the epoch we live in, the Knowledge Age. A generation of collaborative, progressive problem solvers, with strong social values, may be just what we need to overcome the complex world problems we now face.

Appendices

Appendix 1
Connectionist models are examples of the larger class of system dynamics model*s* that exhibit *self-organisation* as an emergent property to explain how simple ideas can be combined to create something more complex. The frequently stated constructivist principle, *Learners construct their own knowledge*, can be restated in dynamic systems terms as "All understandings are inventions; inventions are emergent". (Scardamalia & Bereiter, in press).



(Bereiter, 2002)

> Everyday cognition makes more sense if we abandon the idea of a mind operating on stored mental content and replace it with the idea of a mind continually and automatically responding to the world and making sense of whatever befalls it. (Bereiter, 1997, p. 26)

Bereiter (1997) called this the *connectionist view of mind*. He sees "learning, thinking, knowing, and the creation of new knowledge as forms of self-organization." (Bereiter, 1997, p. 30) He describes an alternative to the mind as container as a "connectionist view of mind as a self-organizing system—a system that does not actually contain mental objects as data but that produces knowledgeable behaviour as an emergent."(Bereiter, 1997, p. 42)

Appendix 2
(Adapted from Bielaczyc & Collins, 2000, p.288)
They listed the following Principles for the design of effective learning communities:

- Community Growth Principle: individual and collective knowledge can expand simultaneously.

- Emergent Goals Principle: A student-centered approach is needed where their needs, interests and abilities are listened to when building goals.
- Articulation-of-Goals Principle: these goals need to be visible and understood by every-one.
- Metacognitive Principle: "Metacognition involves (a) monitoring one's thinking processes, (b) being aware of what one knows and doesn't know, and (c) reflecting on what one has learned (Brown, Bransford, Ferrara, & Campione, 1983)
- Beyond-the-Bounds Principle: An attitude of welcoming new approaches and challenges needs to be fostered, not just ideas that support yours but those that oppose current beliefs.
- Respect-for-others Principle: differences and varying contributions need to be respected and everyone needs to feel safe to contribute their ideas.
- Failure-Safe Principle: an attitude that experimentation and risk taking can lead to failure but that is ok and no one is to blame.
- Structural-Dependence Principle: activities have to make students dependent on each other some way, how the final product or understanding comes about.
- Depth over Breadth Principle: students need sufficient time to investigate topics in enough depth in order to gain real expertise in the topics.
- Diverse-Expertise Principle: allow student to investigate the areas in which they are most interested and capable, with the responsibility that they share their expertise with the other students and the teacher.
- Multiple-Ways-To-Participate Principle: allow for diversity of interest and ability by offering a range of activities - formulating questions, gathering knowledge, sharing knowledge within the community, presenting their knowledge to the outside world, and reflecting on what they have learned. All roles and contributions need to be valued.
- Sharing Principle: each student is a learner and a contributor to the community knowledge.
- Negotiation Principle: reaching joint ideas and decisions is important but it is also important to respect critique from others without it being personal.
- Quality-Of-Products Principle: invite audiences to judge the work such as parents, community members and other students.

Appendix 3

Hakkarainen et al. (2002) describe the following subtasks in progressive inquiry:

a. Creating the context
b. Setting up research questions
c. Constructing working theories
d. Critical evaluation
e. Searching deepening knowledge
f. Generating subordinate questions and
g. Constructing new working theories.

All phases are in a flexible order repeated several times and ideas are shared among peers using a network-based platform supporting collaboration.

Appendix 4

Description of a classroom-based Knowledge Building Community (Scardamalia and Bereiter, 1993, pp. 14-15. cited in Hewitt 2004 p. 216-217)

1. There is a sustained study of topics in depth, sometimes over a period of months, rather than superficial coverage.
2. The focus is on problems rather than on categories of knowledge.
3. Inquiry is driven by student's questions. The teacher helps students formulate better questions and encourages them to reformulate questions at higher levels as inquiry proceeds.
4. Explaining is the major challenge. Students are encouraged to produce their own theories to account for facts and to criticise one another's theories by confronting them with facts.
5. Although teachers pay close attention to hew each student is doing, the day-to-day focus is progress toward collective goals of understanding and judgment rather than on individual learning and performance.
6. There is little schoolwork of the conventional kind, where the students are working individually but all doing the same thing. More typically, students work in small groups; each group has a different task related to the central topic and plans how to distribute work among its members.
7. Discourse is taken seriously. Students are expected to respond to one another's work and are taught how to do so in helpful, supportive ways.
8. The teacher's own knowledge does not curtail what is to be learned or investigated. Teachers can contribute what they know to the discourse, but there are other sources of information.
9. The teacher remains the leader, but the teacher's role shifts from standing outside the learning process and guiding it to participating actively in the learning process and leading by virtue of being a more expert learner. (Scardamalia and Bereiter, 1993, pp. 14-15)

Appendix 5

(Scardamalia, 2002, p.9-12)

12 Socio-cognitive and Technological Determinants of Knowledge Building.

1. Real ideas, authentic problems,
2. Improvable ideas,
3. Idea diversity,
4. Rise above (synthesise ideas, reduces redundancy)
5. Epistemic agency (student ideas, student direction),
6. Community knowledge/collective responsibility,
7. Democratising knowledge,
8. Symmetric knowledge advancement,
9. Pervasive knowledge building,
10. Constructive uses of authoritative sources,
11. Knowledge building discourse,
12. Embedded and transformative assessment.
    (Scardamalia, 2002, p.9-12)

Appendix 6

Listed below are the characteristics of these successful Knowledge Building classes. I have compiled them from Hewitt (2004)

- Students did not focus on completing teacher designated tasks (e.g. worksheets, assignments, projects) The students actively and collaboratively defined research problems that interest them, developing plans, identifying intellectual impasses,

synthesising ideas, and generally working with others to make sense of their area of inquiry." (p.211-212)

- The teacher is seen as the expert learner in the classroom, one who supports and mentors students in their knowledge building efforts." (p.212)
- The primary enterprise is knowledge creation rather than the construction of a specific products or the completion of tasks (Riel & Polin 2004, cited in Hewitt 2004 p. 211)
- Students all worked on one topic but specialised in different sub domains, dividing the labour in ways to allow for personal interests of the students.
- To avoid copying passages from references the students were encouraged to take brief notes at their desk, and make an effort to understand what they were reading. They would then take their handwritten notes to the computer during their Knowledge Forum session" (p. 224)
- Notes that were grammatically correct, were free of spelling errors, and made a reasonable contribution to the class discourse were assigned a "published" designation in the database." (Hewitt, 2004, p. 221). To publish a note, a student would approach the teacher at his desk, one-on-one. These meetings were opportunities to suggest profitable directions for future inquiry, or to raise issues that the student had not previously considered.(p. 221)
- "Coaching students in person permitted more rapid conversational exchanges than would be possible in asynchronous environments and it reduced the risk of embarrassing a student in front of his or her peers." Students also come when they are ready to talk. (p.223)
- Publishing gives the student an "incentive for quantity and quality (p.223)
- These interactions help the teacher to evaluate performance and tailor standards of achievement to the needs and abilities of individual students.
- Thus, students became classroom experts in various sub-domains and interacted with each other in the online environment, and felt a sense of ownership over that environment, while the teacher mentored them privately and in-person." (p. 223-224)
- "Perhaps the most distinctive rule in this community was the emphasis on student theories and the tolerance of partial understandings or misconceptions. The teacher wanted the students to feel safe proposing explanations and sharing them with their classmates. Students were allowed to disagree with one another, but only in ways that respected each others work." (p. 225)
- "We are encouraging students to be unafraid of saying what they actually believe and then work towards seeing whether or not they are correct." (p.226)
- "Learning was an active process of improving one's understanding."(p.229)
- "Knowledge Forum technology offered a medium through which learners could engage in knowledge building operations, but the students' sense of mutual trust, their priorities, and their tolerance for each others' ideas were largely forged through face-to-face processes. " (p.230)
- Trust is a key part of teamwork, yet trust is difficult to establish through electronic communication (Kling & Courtright, 2004 Vaillancourt, 2002. cited in Hewitt, 2004, p.235)
- The teacher's role in this is crucial. "The teacher forged this culture of mutual trust and respect in his day-to-day classroom interactions with students." (Hewitt, 2004, p. 233)

Appendix 7

Table 1. Guidelines on Knowledge Building Principles and Portfolios

You need to select four best clusters of notes together with a summary note that explains why you have selected the notes. Use the principles and criteria to help you with note selection.
Principle One: Working at the Cutting Edge ● Identify knowledge gaps, inconsistencies and ask productive questions ● Pose problems that extend the edge of understanding of the community ● Pose problems with potential for continual discussion and inquiry (i.e., interest many people)
Principle Two: Progressive problem solving ● Show continual efforts to grapple with problems posed by classmates ● Pose notes aimed at addressing the original problem and questions arising from them ● Show sustained inquiry: Identify the problem, solve the problem, but keep asking new questions ● Reinvest efforts to keep solving new problems to improve ideas
Principle Three: Collaborative Effort ● Use various KF functions such as references and rise-above to make knowledge accessible ● Summarize different ideas and viewpoints and put them together as a better theory ● Help classmates to extend and improve their understanding ● Encourage classmates to write notes that follow the other principles
Principle Four: Monitoring Own Understanding ● Explain what you did not know and what you have learned ● Recognize discrepancies and misconceptions and new insights; trace own paths of understanding ● Show your new ways of looking at things (questions, ideas, issues) after examining other KF notes
Principle Five: Constructive Uses of Different Sources of Information ● Use information from other sources (Internet, newspaper…etc) to support or explain your ideas ● Bring together classroom learning, information from textbook, classmates' KF notes ● Provide contrasting or conflicting information to what is printed in the textbook

Appendix 8

Paavola et al. (2004) The characteristics of the Knowledge Creation metaphor:

- The pursuit of Newness
- Mediating Elements to Avoid Cartesian Dualism
- Viewing Knowledge Creation as a social process-

- Emphasis on the Role of Individual Subjects in Knowledge Creation –
- Going Beyond Propositional and Conceptual Knowledge
- Recognizing Conceptualisations and Conceptual Artifacts as Important
- Interaction Around and Through Shared Objects

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