

Epistemological Foundations for CSCL: A Comparison of Three Models of Innovative Knowledge Communities

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ABSTRACT

CSCL is based on the idea that computer applications can scaffold and implement advanced socio-cognitive processes for knowledge sharing and knowledge building. But do we really understand these processes that are supposed to be implemented? This paper will focus on the "epistemological infrastructure" of CSCL. We will analyze three models of innovative knowledge communities in order to better understand basic epistemological processes of knowledge advancement: i.e., Nonaka and Takeuchi's model of knowledge-creating organization, Yrjö Engeström's expansive learning model, and Carl Bereiter's theory of knowledge building. It is argued that these models provide a way of overcoming the dichotomy of the acquisition and participation metaphors of learning by providing a third metaphor of learning as a process of knowledge creation. In order to facilitate educational change through CSCL also certain kind of larger social infrastructure is needed that supports these epistemological processes.

Keywords: knowledge-creation metaphor; epistemological infrastructure, knowledge building, innovative knowledge community

INTRODUCTION: KNOWLEDGE-CREATION METAPHOR OF LEARNING

Processes of innovation and discovery are not easy subjects to analyze. In philosophy of science it has been customary to separate the context of discovery and the context of justification (see e.g., Nickles 1980) and to claim that only the latter is subject to conceptual analysis. There have been some very significant exceptions -- e.g., N.R. Hanson (see 1972) in the 1950s and 1960s -- but the general view has been that the processes of discovery are something that cannot be captured with conceptual means. Nowadays this clearcut distinction is often challenged in philosophy of science. There are some notable models that try to conceptualize processes of discovery (see e.g., Hintikka 1985, Sintonen 1996), but still the idea often is, that discovery in genuine sense is something that is not susceptible to conceptual analysis (see Nickles 1980).

The need to understand innovative learning and innovative knowledge advancement is felt in various fields, especially in education, cognitive science, and in business sciences (Nonaka & Takeuchi, 1995; Bereiter, in press). The purpose of the present article is to examine models of innovative knowledge communities that address the problem of explaining how knowledge advancement takes place. All of these models are focused on examining knowledge advancement at a communal level and provide potential models for implementing practices of CSCL in education. Simultaneously, the models challenge our notions of what learning and knowledge are all about. It can be maintained that in these models learning is understood through, what we call, a knowledge-creation or knowledge advancement metaphor. *The knowledge-creation metaphor* of learning means that learning is seen as analogous to processes of inquiry, especially to *innovative* processes of inquiry where something new is created and the initial knowledge is either substantially enriched or significantly transformed during the process.

Anna Sfard (1998) has distinguished two metaphors of learning, *the acquisition metaphor* and *the participation metaphor*. The former represents a traditional view according to which learning is mainly a process of acquiring desired pieces of knowledge. The acquisition metaphor appears to rely on a 'folk theory' of mind according to which the mind is a container of knowledge, and learning is a process that fills the container, implanting knowledge there. Or in other terms, learning is a matter of individual construction, acquisition, and such outcomes, which are realized in the process of transfer; it consists in a person's capability to use and apply knowledge in new situations. Knowledge is a property and possession of an individual mind (for a recent criticism of the mind-as-a-container metaphor from the point of view of education, see Bereiter, in press).

An alternative model, according to Sfard, is the participation metaphor of learning that examines learning as a process of participating in various cultural practices and shared learning activities. According to it, the focus is on activities, i.e., on "knowing", and not so much on outcomes or products, i.e., on "knowledge" in the traditional sense. Knowledge does not exist either in a world of its own or in individual minds but is an aspect of participation in cultural practices (Brown, Collins, & Duguid, 1989; Lave, 1988; Lave & Wenger, 1991). Cognition and knowing are distributed over both individuals and their environments, and learning is "located" in these relations and networks of distributed activities of participation. Within the participation metaphor, learning is a matter of participation in a social process of knowledge construction (Greeno, 1998; Vygotsky, 1978), "enculturation" (Brown, Collins, & Duguid, 1989), guided participation (Rogoff, 1990), or legitimate peripheral participation (Lave & Wenger, 1991). If one reads through the recent papers published in CSCL research (e.g., Dillenbourg, Eurelings, & Hakkarainen, 2001; Hoadley, 1999) most of them appear to rely on the wide sociocultural framework.

The notion of learning through participation was, however, originally used to characterize educational practices in certain aboriginal (e.g., midwives at Yucatan or tailors of Ivory Coast, Lave & Wenger, 1991) or traditional (e.g., insurance-claim processors, Wenger, 1998) cultures that appear, however, to be relatively stable. It is typical for those using the many variations of the participation metaphor to examine how knowledge is transmitted from one generation to another without substantial and deliberate changes or cultural transformations. Many researchers argue, however, that one simply cannot understand the fundamental changes in modern knowledge society, such as emergence of work focused on deliberate knowledge advancement, by examining how people grow up from peripheral to full participation or how novices learn gradually to master experts' knowledge and skills (see Ahonen, Engeström, & Virkkunen, 2000; Bereiter, in press). In modern knowledge communities, it is argued, there are not such clear-cut roles for newcomers and old-timers (only old-timers having access to the most valuable knowledge and skills) because everyone has to function as a newcomer in a sense of continuously surpassing his or her earlier achievements, and because sometimes new generations develop competencies that are very difficult for older generations to attain (see Bereiter & Scardamalia, 1993).

The distinction between the acquisition metaphor and the participation metaphor has its roots in a debate between cognitive and situated (or situative) perspectives of learning (see Anderson, Reder & Simon 1996, 1997; Greeno 1997). Cognitive approaches emphasize computational models of mind, and the aim is to simulate the way the individual mind operates with knowledge. Situated approaches emphasize situatedness of human cognition, and participation in interactive, social processes as basic processes in learning. A cognitive perspective emphasizes *knowledge*, whereas a situated approach emphasizes participation in social *practices* and *actions* (Anderson, Reder & Simon 1997).

In order to develop a framework that would help one to understand innovative knowledge communities that are emerging in the knowledge society, it appears to be necessary to go beyond the acquisition and participation dichotomy. The present investigation explores the knowledge creation metaphor of learning that appears to help to overcome the separation of the cognitive (the acquisition metaphor) and the situative (the participation metaphor) perspectives. Knowledge creation means that knowledge is emphasized (as in the acquisition metaphor), but not as such but according to the processual point of view. In the participation metaphor "the permanence of *having* gives way to the constant flux of *doing*" (Sfard 1998, 6). But in the knowledge creation metaphor it is not just the situatedness of action, and participation on social interaction that is emphasized but rather the process of developing and creating *knowledge*.

We analyze and compare three models of innovative knowledge communities, i.e. the model of knowledge creation by Ikujiro Nonaka & Hirotaka Takeuchi, the model of expansive learning by Yrjö Engeström, and the model of knowledge building by Carl Bereiter. At the outset, these models appear *not* to have much in common. Nonaka and Takeuchi's framework concerns especially the area of knowledge management and how to organize firms to operate in an innovative way. Engeström's model is strongly rooted in the tradition of cultural-historical activity theory, which seeks to analyze and change practices of learning and working-life. Bereiter's theory is a new way of understanding what is important in education based on the criticism of the folk theory of mind and knowledge. At the outset, we acknowledge that there are many differences in these frameworks, and a comparison cannot capture all aspects of these models. But still, the comparison turns out to be fruitful (see also Engeström 1999, Bereiter, in press).

These models represent attempts to determine how epistemic communities should be organized in order to facilitate knowledge advancement and creation. The models appear to provide valuable guidance for restructuring school according to innovative knowledge communities through helping teachers and students work deliberately for advancing their knowledge, and supporting them in reflecting on and transforming of their communities. Bielaczyc (2001) has argued that in order to facilitate educational change through CSCL it is not enough to implement CSCL tools but one also needs an appropriate *social infrastructure*, i.e., social structures and practices that support desired interaction between the participants. We will argue that besides technical and social infrastructure, educators and

educational psychologists should also consider the epistemological foundations of CSCL. These involve theories or models that help to understand the role of different agents (e.g., individuals, communities, networks) in knowledge creation, mechanisms of knowledge advancement (e.g., resolving epistemic contradictions or explicating implications of existing knowledge), nature of knowledge (to what extent knowledge is "in the head" or "in the world"), and processes of inquiry (the role of questions and theories) involved. By comparing models of innovative knowledge communities, our aim is to better understand the "*epistemological infrastructure*" of CSCL and collaborative learning in general. Epistemological infrastructure refers to individual and collective practices of working with knowledge and engaging in inquiries for advancing knowledge that are important in knowledge work.

THREE MODELS OF INNOVATIVE KNOWLEDGE COMMUNITIES

Ikujiro Nonaka and Hirotaka Takeuchi have presented a very famous and influential model of the innovation process in their book, *The Knowledge-Creating Company* (1995). The basis of their model is an epistemological distinction between two sorts of knowledge, i.e., tacit and explicit. Explicit knowledge means knowledge that is easy to articulate and express formally and in clear terms. Tacit knowledge, which is more important in innovation, means "personal knowledge embedded in individual experience and involves intangible factors such as personal belief, perspective, and the value system" (viii). Another starting point in their model is an "ontological" distinction between different levels of "entities" that operate in knowledge creation, i.e., individual, group, organizational and inter-organizational level. According to Nonaka and Takeuchi knowledge is created and transformed "spirally" from individual level to organizational level and finally between organizations.

The dynamics of this model comes from the interaction between tacit knowledge and explicit knowledge. A "knowledge spiral" is based on four alternative types of knowledge conversion, i.e., a) from tacit knowledge to tacit knowledge, which Nonaka and Takeuchi call *socialization*, b) from tacit to explicit knowledge, i.e., *externalization*, c) from explicit to explicit knowledge, i.e., *combination*, and d) from explicit to tacit knowledge, i.e. *internalization*. The knowledge creation spiral can be understood so that it starts from *socialization*, when tacit knowledge and experiences are shared at the group level. This means a close interaction and collaboration within a group. This socialization creates common understanding and trust within the group. The next phase, *externalization*, is the central phase in knowledge creation. It means that tacit knowledge is explicated and conceptualized by using metaphors, analogies and concepts. In Nonaka and Takeuchi's model, tacit knowledge is the basic source of innovation, but it must be explicated in order to be transformed to knowledge that is useful at a group level and to the whole organization. *Combination* means that already existing explicit knowledge is combined and exchanged. Finally, *internalization* means that explicit knowledge at the group or organizational level must be internalized into individuals' tacit knowledge and into action in order to have real effects in organization. After internalization a new round in the knowledge spiral can start again.

Yrjö Engeström has analyzed Nonaka and Takeuchi's model and presented the theory of expansive learning as an alternative and a more extensive model for innovative learning (Engeström 1999). He has studied innovative learning cycles in work teams using cultural- historical activity theory, and the theory of expansive learning as a framework for his analysis (see also Engeström 1987). Engeström's model is based on a learning cycle with seven stages in its ideal form (383-384; cf. Engeström 1987, 188-191, 321-336). The cycle starts by 1) individual subjects *questioning* and criticizing of some accepted practices, by certain individuals; which is followed by 2) *analyzing* the situation, i.e., analysis of those (historical) causes and empirical inner relations that are involved in the activity system in question. Then participants engage in 3) *modeling* of a new solution to the problematic situation. They often are 4) *examining the new model* by experimenting and seeing how it works, and what potentialities and limitations it has. Participants undertake 5) *implementing the new model* to practical action and applications, and then, 6) *reflecting* on and evaluating the process. Finally, participants engage in 7) *consolidating the new practice* into some new form of practice. Innovative learning cycles do not follow any fixed order. The model should be understood more as an ideal or heuristic for analyzing elements in the expansive learning cycle. Engeström makes no claim that these steps universally follow one another in just this particular order.

According to Engeström, the central problem with Nonaka and Takeuchi's model is that it does not take into account the first two phases in the expansive cycle, i.e., questioning and analyzing the situation. Their model is based too much on the idea of sharing tacit knowledge in the socialization phase and does not take into account the importance of controversies and conflicts in knowledge creation. These phases are, according to Engeström, excluded, and the problems are taken as given or treated as defined by the management (without analyzing how they originate) in Nonaka and Takeuchi's model. Table 1 presents a schematic representation of the relations between the innovative communities as depicted in the three models examined here.

Table 1. Frameworks for Understanding Innovative Knowledge Communities

	Nonaka & Takeuchi	Engeström	Bereiter
The role of individual expertise	Black box, individuals create knowledge	Socially embedded	Theory of expertise
Main focus	Tacit knowledge (insighting)	Knowledge embedded in practices (acting)	Knowledge objects (conceptualizing)
Type of processes focused	Emphasize bodily processes, personal experience	Emphasize material object-oriented activities	Emphasize solving of knowledge problems
Source of innovation	Transforming tacit knowledge to explicit knowledge	Overcoming tensions, disturbances, and ambiguities by expansive learning	Working deliberately for extending and creating new knowledge objects
Scope of framework	Different ontological levels (individual, innovative team, organization, and inter-organization level)	Activity systems and networks of activity systems	Knowledge-building communities
Educational application	Knowledge-creating schools	Expansive learning school	Schools as knowledge-building communities

Carl Bereiter has also criticized Nonaka and Takeuchi's model on the grounds that it is still rooted in mentalistic "folk epistemology". Nonaka and Takeuchi's model is based on the externalization of tacit knowledge and appears to rely on a mentalistic assumption that knowledge resides and is created in an individual's head. What is missing from this model is knowledge "in the world" that Bereiter considers as "conceptual artifacts". He proposes that the development of a knowledge society has given rise to dealing with knowledge as a thing that can systematically be produced and shared between members of a community. Due to mentalistic assumptions, Nonaka and Takeuchi's model is unable to capture essential features in knowledge work, i.e., how knowledge is created, understood, and used in collaborative knowledge building. The concept of knowledge building refers to collective work for the advancement and elaboration of conceptual artifacts, such as theories, ideas, and models, the entities of Popper's World 3 (i.e., the world of cultural knowledge). Popper emphasized that besides physical and material reality (World 1) and reality that concerns mental states (World 2), there is third realm (World 3) which includes conceptual things such as theories and ideas. This World 3 is especially important for humans because human beings do not operate only in the mental realm but can understand and develop objects belonging to this third realm. Although World 3 is dependent on World 2 and World 1, it is still quite autonomous. Bereiter has criticized theories of learning that do not take into account World 3 and so are based on the *mind-as-a-container metaphor*; i.e., an idea that learning relies on accumulation of a ready-made information to the human mind, and mind is understood as a kind of a container or an archive.

An important aspect of Bereiter's (in press) theory is to make a conceptual distinction between learning and knowledge building. In modern enterprises and science, knowledge is considered to consist of objects (e.g., product plans, business strategies, marketing plans) that can be systematically produced and developed. Correspondingly, scientific research groups are typically working with theories and models that may be understood as shared knowledge objects rather than as representing mental states. Naturally, learning also does occur in the business world and scientific research, but it is not the main focus of these domains of activity. The primary goal of members of an innovative expert community is not merely to learn something (i.e., change, or simply add to, their own mental states), but to solve problems, originate new thoughts, and advance communal knowledge. But in knowledge building knowledge work is seen as a collaborative achievement, where people develop, create, understand, and criticize various conceptual artifacts, not just "learn" something (i.e., understand in their own minds something already existing). Bereiter's theory diverges from the other two models in the sense that he emphasizes more strongly a conscious effort to advance knowledge and a commitment go beyond existing knowledge and understanding, an effort to solve knowledge problems through collaboration in innovative communities within a knowledge society.

A COMPARISON OF THE THREE MODELS OF INNOVATIVE COMMUNITIES

In spite of differences between Nonaka and Takeuchi's, Engeström's, and Bereiter's models, they have many features that are in common. First of all, they can be seen as instances of the knowledge creation metaphor, instantiations that have many similarities. The focus of Nonaka and Takeuchi's book is "on knowledge *creation*, not on knowledge per se" (Nonaka & Takeuchi 1995, 6). Engeström's model concentrates on expansive, qualitative changes in activity systems (Engeström 1987). Bereiter's model is based on dynamic expertise and progressive problem solving where the goal always is to surpass previous achievements (Bereiter & Scardamalia 1993). It is no coincidence that this kind of innovative learning is characterized with some sort of a spiral or a cycle (see Engeström 1999, 383-384; Nonaka & Takeuchi 1995, 70-73). The processes of knowledge creation usually take a lot of time. They are iterative and recursive processes which are not correctly described by traditional narratives of heroic individuals making ingenious discoveries through sudden moments of insight. They are not linear process, either (Engeström 1987, 214). Knowledge creation is more based on ambiguity and "creative chaos" (Nonaka & Takeuchi 1995, 78-80). Creative chaos does not mean destructive chaos, but involves the sense of progress.

Secondly, all of the three frameworks challenge attempts to restrict our understanding of knowledge exclusively to conceptual or propositional knowledge. Propositional knowledge is one important form of knowledge but it is only one form of knowledge. The models emphasize knowledge which can be called *know-how* and *tacit knowledge*. Bereiter and Scardamalia (1993, 43-47) have described a distinction between three basic areas of knowledge: 1) declarative knowledge which means "formal" or propositional knowledge, 2) procedural knowledge or know-how (Gilbert Ryle's term) which means knowledge embedded in skills, and 3) "hidden knowledge" or "tacit knowledge" (Michael Polanyi's term), which is based on such things as impressions and a "sense" of things. These models of innovative learning criticize the traditional view according to which human cognition is a symbolic system that mainly relies on explicit propositional knowledge and functions according to explicitly formed production rules. The emphasis on explicit knowledge can lead to so-called "paralysis by analysis" syndrome (Nonaka & Takeuchi 1995, 198). Rylean know-how is based on the idea that our activities and skills are not guided by explicit rules and propositional knowledge; rather, rule-like behavior emerges as an outcome of knowledgeable action (summarized in Bereiter, in press).

Besides declarative and procedural knowledge, there is the third area of knowledge, i.e., tacit knowledge, which is highly important in Bereiter's model of expertise. Skills and know-how are things that manifest themselves in performance, but tacit knowledge is much harder to recognize directly. Still, creative expertise is very much based on tacit knowledge concerning promising ideas (Bereiter & Scardamalia 1993, 133- 152). Based on experience of solving problems concerning their own field, creative experts have some sort of sense of what is promising in their field and how to solve new problems. And creative experts are also all the time consciously trying to find out new and more promising ways of doing things in their field. There is always venturesome and risky effort, but this uncertainty is part of innovative processes. Similarly Nonaka and Takeuchi emphasize tacit knowledge in their model. According to them tacit knowledge includes subjective insights, intuitions, hunches, and ideals, which are the crucial basis for innovative processes (Nonaka & Takeuchi 1995, 8-10).

Thirdly, although these models of innovative learning criticize propositional and conceptual knowledge when it is seen as the only form of knowledge, they still emphasize the role of *conceptualization* in innovative processes. Bereiter's model is based on the idea of conceptual artifacts and of solving problems of understanding. In Nonaka and Takeuchi's model, one key process is the externalization of tacit knowledge. And in Engeström model an important phase in an expansive learning cycle is *modeling*, i.e., constructing an explicit model that offers a new solution to the situation in question. So it appears that an important point in these models of innovative learning is the "dialectical" interaction between different forms of knowledge.

Fourthly, all these models try to avoid mentalism and Cartesian dualism. It can be argued that this is done by bringing some mediating element to the process of knowledge creation (although in Nonaka and Takeuchi's model this is not so obvious). Bereiter emphasizes objects in World 3 that are neither part of the material realm (World 1) nor part of the subjective, mental realm (World 2). Engeström emphasizes the element of "thirdness" in his model in order to avoid mentalism (Engeström 1987, 221-222, 302-304). The concepts of activity and dialectics operate as mediating factors that bring dynamics to the model (140, 310). Nonaka and Takeuchi try to avoid the "Cartesian split" between subject and object (which is, according to them, typical of Western thought) by referring to the Japanese way of thinking. Japanese tradition does not do separate humanity and nature, body and mind, nor self and others so sharply as the Cartesian tradition has done (Nonaka & Takeuchi 1995, 20-32). The Japanese view sounds a little bit mysterious, but the idea is that knowledge and rationality is not so clearly separated from things such as

emotions, figurative speech, actions, and so on; in the processes of innovation these vague and even chaotic elements are the fuel for something new.

From Bereiter's viewpoint, Nonaka's model is still rooted in the folk psychological theory of mind because the latter so strongly emphasizes embodied and tacit knowledge that appears to be contained within an individual human mind. This is one basic difference in Bereiter's and Nonaka and Takeuchi's model, because in Nonaka and Takeuchi's model there is no explicit room for *conceptual artifacts*. But the difference between these models may not actually be so large. Bereiter himself acknowledges that Nonaka and Takeuchi's model goes as far as is possible in the folk psychological way of thinking about knowledge creation. It is important to notice the knowledge spiral in Nonaka and Takeuchi's model; that knowledge is produced collaboratively (and not only in individual minds); and that the explication of knowledge to group and organizational level is focal.

Questions and problems also have a mediating role in these models. In Bereiter's model, questions, and problems of understanding are the moving force for progressive knowledge building (Bereiter 1993, 210- 211). In Engeström's model the questioning and criticism of accepted practices is the basis for the expansive learning cycle (Engeström 1999, 383). Engeström, as already stated, criticizes Nonaka and Takeuchi's model that it does not take into account phases of formulating and debating a problem, or takes these phases more or less as given (ibid., 380) {said}. One reason for this difference might be that Engeström has analyzed knowledge creation in *western* organizations whereas Nonaka and Takeuchi worked especially in *Japanese* organizations. In Japanese culture, harmony and group thinking are much more strongly emphasized than in western culture, where the meaning of individual differences and also conflicts are more easily taken as a starting point (see Nonaka & Takeuchi 1995, 31, 63). But it appears that both of these aspects, the creation of mutual trust and understanding by strong socialization, and the opportunity and acceptance for criticism and questioning, are needed in knowledge innovation. As a matter of fact, although Nonaka and Takeuchi do not emphasize conflicts or questions in their model, these topics are not totally left out either. Socialization in their model involves dialogue and discussion, and "[t]his dialogue can involve considerable conflict and disagreement, but it is precisely such conflict that pushes employees to question existing premises and to make sense of their experience in a new way" (1995, 13-14).

Fifthly, All of the frameworks agree that knowledge creation is a fundamentally social process in nature. They appear to share with Naomi Miyake the view according to which social interaction provides cognitive resources for human cognitive accomplishment (Miyake 1986). According to Miyake's analysis, understanding is iterative in nature, i.e., it emerges through a series of attempts to explain and understand processes and mechanisms being investigated. In a shared problem-solving process, agents who have partial but different information about the problem in question appear collectively to improve their understanding through social interaction. Accordingly, new ideas and innovations emerge among rather than within people.

Sixthly, although innovation processes are fundamentally social in nature, individual activity is also emphasized; not individuals separately, but individuals acting as a part of social stream of activities. In Engeström's model, although individual activities are embedded to their cultural-historical background, it is *individual* subjects questioning the accepted practices, which is the starting point for the expansive learning (Engeström 1999, 383; 1987, 322). Nonaka and Takeuchi emphasize that new knowledge always starts with an individual (Nonaka & Takeuchi 1995, 13, 59). In their model the role of individuals seems to be more central than in Engeström's or Bereiter's model. In this model, it is still individual initiative embedded in group and organizational activities. Nonaka and Takeuchi criticize Western tradition, arguing that it is too much focused on the individual subject and largely abandoned the social interaction. Knowledge conversion is, in a fundamental way, a social process and "not confined *within* an individual" (Nonaka & Takeuchi 1995, 61; see also 31-32, 226). However, individuals appear to be taken as given in Nonaka and Takeuchi's framework; they talk a great deal about individual heroes that pursue processes of innovation but remain, to a large extent, unanalyzed black boxes. The idea of individual transformation through collective activity is much stronger in Bereiter's and Engeström's frameworks.

CSCL AND MODELS OF INNOVATIVE KNOWLEDGE COMMUNITIES

Fjuk and Ludvigsen (2001) argued that the educational implications of CSCL can be understood only by extending the unit of analysis from technology and pedagogy to those social contexts in which CSCL is used. They argued that it is important to investigate how real-life situations in which people are using CSCL develop across extended periods of time rather than just focus on short courses. Traditional approaches to CSCL -- including sometimes our own approaches -- have suffered from a too narrow theoretical and methodological orientation that has guided researchers to look at individual classrooms and courses rather than consider larger social structures and how they may constrain participation in CSCL. Success of CSCL experiments has, however, usually been constrained by various organizational (i.e., content of the curriculum, boundaries between classrooms as well as between domains of knowledge), pedagogical (prevailing practices of learning and instruction), and epistemological (fact-centred

educational epistemology and knowledge-delivery orientation) factors (e.g., Hakkarainen, Lipponen & Järvelä, in press). Only gradually have we started to understand that the unit of our analyses has been too small, and it is more and more clear that in order to succeed, one needs to better understand how school communities function and find innovative ways transforming whole educational communities.

The present investigation arises from an attempt to explore models that may guide CSCL researchers in developing more innovative communities of inquirers within an educational system through CSCL. Each of the present models provides its distinct perspective on educational communities and organizations. The models indicate that innovation or intelligence arise from systemic features of whole community or an organization rather than from characteristics of individuals or their work. Knowledge creation is not primarily a matter of creative individuals but requires fundamental reorganization of functioning of a whole epistemic community. The knowledge-creation metaphor appears to have contact with the participation metaphor by emphasizing importance of taking part in certain kind of social practices of working for advancing knowledge. The models of innovative educational communities to be examined below indicate that the epistemological infrastructure of CSCL requires a kind of social infrastructure; mere epistemology is not enough without supporting social practices and structures, and *vice versa*.

Schools as knowledge-building communities

Bereiter and Scardamalia's model of knowledge building school is both historically and conceptually very closely associated with CSCL research. Their seminal work for developing networked environments for computer-supported learning has profoundly affected the formation of our field of inquiry. The present researchers have pursued, over several years, models of facilitating progressive inquiry at school, by relying on Carl Bereiter's theory of knowledge building and Jaakko Hintikka's interrogative approach to inquiry (Hakkarainen, 1998; Hakkarainen & Sintonen, in press). Scardamalia and Bereiter (1994) argued that there are no compelling reasons why school education should not have the dynamic character of scientific inquiry. They proposed (1994) that scientific thinking could be facilitated in schools by organizing schools to function like scientific research communities and guiding students to participate in practices of progressive scientific discourse. Although students are learning already-existing knowledge, they may be engaged in the same kind of extended processes of question-driven inquiry as scientists and scholars. They also proposed that there is a close relation between the processes of scientific discovery and learning scientific knowledge. The argument was that it is essential to cultivate reasoned "processes of invention" that characterize scientific inquiry, to involve students with same kind of extended process of problem solving through which scientists articulate new knowledge.

Simultaneously, however, the theoretical foundations of the knowledge-building approach have profoundly changed from theories of intentional learning and expertise to the theory of collaborative efforts in building knowledge objects, and conceptual artifacts, and solving knowledge problems. One of the best examples of knowledge-building projects in Finland is the Citizen Memory project. Upper elementary school students have been participating in collaboration with local communities in a project that focuses on collecting information about local history. The project aimed at searching for information about how people used to live in the area and how it had changed. The students were guided to interview their grandparents and other elderly people in order to examine how they had been living during earlier periods of time. These interviews were transcribed from audiotapes and posted on the web, together with digitized photographs, so that there emerged a continuously growing body of local knowledge. In so doing, the students engaged in knowledge-building, rather than just learning. They constructed a very rich, organized database that can be used, reorganized and analyzed by other students, researchers or teachers; therefore, their activity went beyond the boundaries of mere learning. Innovative collaborative technology enriches conventional learning situations by a shared space that allows the users to work together for advancement of their knowledge. Educational implications of the Bereiterian line of mature knowledge-building inquiry are, however, just starting to be explicated. There appears nevertheless, to be a need for more guidance concerning how to facilitate organizational processes of change. While struggling with these issues, the present investigators are in a sense facing the very limits of their own expertise in cognitive sciences that do not provide sufficient support for understanding social and organization transformations.

Knowledge-creating schools

Discussion of the concept of intelligent organizations emerging from Nonaka and Takeuchi's work is approaching the educational domain. For instance, David Hargreaves (1999) talked about the "knowledge-creating school." His argument is that in order to answer the challenges of knowledge society, schools and especially teachers and headmasters need themselves to become creators of professional knowledge. This means a deliberate effort to articulate teachers' professional experiences into shareable knowledge within and between schools. In order to help

students to develop skills and competencies needed in knowledge creations, teachers should themselves have personal experience of building their professional knowledge. Hargreaves' makes a very good case for the challenge of teachers' professional development. He does not, however, have anything to say about how to guide students to develop corresponding competencies (see also Engeström, Engeström, & Suntuio, in press). Our own efforts to implement practices of knowledge-building at school have been constrained by the fact that we have often worked just with a few teachers rather than with teachers' pedagogical communities. It is easy to understand at the conceptual level that in order to guide students' knowledge-building processes, teachers should have personal experiences of knowledge creation. Yet we have just started to implement corresponding practices.

Expansive Learning at Schools

While traditional theories of learning focused only on individual learning and addressed acquisition of some relatively well-defined knowledge or skills, activity theory focuses on examining transformations in an activity system (Engeström, xxxx). It appears to provide tools that help to examine relations within networks of activity systems as well as address larger processes of socio-cultural transformation in the context of CSCL (Fjuk & Ludvigsen, 2001). Engeström, Engeström, and Suntuio (in press) carried out an eleven-week change-laboratory intervention with a teacher community of a middle school. They pointed out that there are several factors that make transformation of school very difficult, such as social, spatial, and temporal structures embedded in classroom-based studies (study of autonomous texts for exams and grading) and teachers' tradition of working as individual professionals. These fundamental constraints make it very difficult for participants to collectively reflect on their practices and engage in sustained expansive learning. Expansive learning is a process of systematically exploring possibilities of transformation through asking questions, generating models and artifacts, and testing and experimenting with new practices.

The change laboratory focused on making constraints visible to the participants and helping them to surpass those challenges. The intervention focused on identifying developmental challenges of the activity system of the school, collectively constructing a vision of the school's future, and implementing a series of practical changes. Toward this end, the researchers videotaped classroom lessons and interviewed teachers, students, and parents. These recordings provided a "mirror" that helped the teacher community to collectively discuss their current practices in relation to its historical formation and trajectories of future development. Researchers thus helped a teacher community to reflect of its current practices, determine the basic tensions and contradiction in it, and identify a collective zone of proximal development. One of the issues that arose in change-laboratory meetings was the integration of different domains of knowledge in constructing of students "final project" just before they left the school. The final project appeared to function as a boundary object that helped to transform a traditional school learning task into a more meaningful one, go beyond requirements of school work and curricular requirements, and simultaneously improve one's school grades. Expansive possibilities opened up also because more positive talk about students was associated with teachers' discussion of the final projects. Through exploring various ways of conducting the final work, the students appeared themselves to be active participants in the process of transforming their practices of schooling, and they engaged in expanding their own and their fellow students' perspectives.

The above examples do not, as such, represent CSCL but it would be natural to utilize CSCL environments both for helping teachers to share and reflect on their experiences, coach students and carry out various kinds of individual and collaborative projects. A number of CSCL studies are either relying on ideas of knowledge-building or utilizing activity-theoretical frameworks. It appears to us that it is important to focus more attention of the CSCL community of investigators on these broader socio-cultural processes, develop corresponding new methods and theoretical frameworks, and pursue corresponding lines of empirical inquiry. In order to use CSCL to increase the quality of learning, we should take school communities into the center rather than periphery of our discussion. The above discussion indicates that the three innovation models explored open up interesting and promising lines of inquiry that are likely to help us to bring about revolutionary changes in schools.

CONCLUSION

We have delineated epistemological foundations for collaborative and innovative learning by comparing three influential models of innovative epistemic communities. We have argued that in these models learning and knowledge advancement is understood through a knowledge-creation metaphor that emphasizes the importance of going beyond information given. All of them are trying to answer to the challenge of the "learning paradox" by focusing on processes of innovation. The learning paradox (or the "Meno paradox") is the classical problem of explaining how something conceptually more complex is created using existing knowledge (see Bereiter 1985).

These three models of innovation take the learning paradox to be a basic epistemological question by highlighting the importance of explaining how something new is created.

There are many similarities in how these models try to avoid the learning paradox. First of all, they concentrate on explaining dynamic processes of knowledge transformation. This is not self-evident. Often models of learning are based on the acquisition metaphor of learning where knowledge is taken more or less as such, and not from the point of view of knowledge *creation*. Or alternatively, the emphasis is on the participation in social interaction but not so much in *knowledge* creation. Secondly, there are many similarities in how these models understand knowledge. They avoid mentalism and a too individualistic approach by criticizing the classical conception of knowledge, as propositional knowledge only. Within the three models, knowledge is seen as a part of dynamic processes of innovation embedded in various skills, emotions, and hunches of the people involved. Thirdly, these newer models emphasize the elements of *mediation* in knowledge creation. They avoid the Cartesian dualism of mind and matter by bringing in conceptual artifacts, theories, activities, questions, problems, metaphors, dialectics, as mediating factors to epistemological processes. Fourthly, these models try to avoid a dichotomy of individual and social levels by concentrating on analyzing how individuals act as participants in innovative processes of knowledge creation.

Although the present paper emphasize similarities between the three models, there are also fundamental differences in philosophical and epistemological foundations of the models that make them even more interesting. One difference is with respect to the fundamental target or object of innovation. In Nonaka and Takeuchi's model, the focus is on ideas and insights related to new products that are developed in firms. In Engeström's model, activities and practices are the main focus. Bereiter, however, emphasizes the meaning of conceptual artifacts and objects in world 3 in knowledge work. In epistemological domain, however, the three models appear to be close to each other because they address the same kinds of questions concerning how new knowledge is created by innovative communities. In collaborative knowledge advancement it is important to expansively transform both ideas, practices, and conceptual artifacts. In this sense the three models complement each other.

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