JrnlID 11412_ArtID 9064_Proof# 1 - 06/03/2009

Computer-Supported Collaborative Learning
DOI 10.1007/s11412-009-9064-x

A knowledge-practice perspective on technology-mediated learning

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Received: 6 May 2008 / Accepted: 27 February 2009

Abstract The purpose of the present paper is to examine the relations between Carl Bereiter's and Marlene Scardamalia's knowledge-building approach and social practices. It is argued that technology enhances learning through transformed social practices. In order to truly contribute to educational transformation, pedagogical approaches have to be embedded in locally cultivated "knowledge practices" that channel the participants' intellectual efforts in a way that elicits collective advancement of knowledge. Consequently, knowledge advancement is not just about putting students' ideas into the centre but depends on corresponding transformation of social practices of working with knowledge. Creation of cultures which advance knowledge presupposes sustained efforts of teacher-practitioners, collaborating with students and researchers, aimed at iteratively transforming prevailing knowledge practices toward more innovative ones.

Keywords Epistemic artifact · Habitus · Knowledge building · Knowledge practice · Learning · Social practice · Trialogical approach

Introduction

The purpose of the present article is to reflect theoretically on relations between Bereiter's (2002) knowledge-building framework and social practices. Pioneering efforts of Bereiter and Scardamalia (2003) have produced the "knowledge-building" framework that has for a long time been an icon of innovative education around the world. This approach appears to capture certain very important aspects of expert-like, creative working with knowledge that assists in improving the quality of education from elementary to higher education. The argument developed in the present position paper is, however, that careful examination of the role of social practices in learning and knowledge building would facilitate further

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advancement of this research program, on a more secure foundation. The motivation of writing this paper is not so much to criticize Bereiter's position as to further organize my own thoughts on the present issues. It appears that in order to make a stronger impact on educational transformation, the knowledge-building approach should be developed in a direction that better takes social practices into consideration. While the knowledge-building framework involves an implicit theory of social practices examined later in this paper, that is not enough. We shall proceed to lay out the reasons for the claim that in order to foster advancement of the approach, one needs a more unified framework that acknowledges the role of social practices.

On the basis of more than 12 years' experience of studying computer-mediated learning, my colleagues and I have concluded that *technology enhances learning through transformed social practices* (Hakkarainen et al. 2006; Muukkonen and Lakkala 2009; Paavola et al. 2004). It appears important to acknowledge that research and development of computer-mediated learning has often (implicitly if not explicitly) relied on the rather naive assumption that technology-enhanced learning environments somehow, by themselves, transform educational practices. On the basis of such illusory hopes, investigators often characterize their technical environments as "innovative," "dynamic," "interactive," "powerful" or use some other supposedly desirable characterizations (for criticism of such approaches, see Engeström 2009).

As Perez (2002) argued, however, technological and social innovations are interdependent. It appears that the technology as such does not determine the nature of its implementation but coevolves with gradually transforming institutional practices (Tuomi 2002). Such a process does not usually involve mechanical assimilation of already existing tools or mere passive adaptation for their affordances, but a reciprocally creative process in which tools evolve to better facilitate intended practices and novel practices are created in order to make better use of novel possibilities provided by technologies. Only when ICT-based tools in general and collaborative technologies in particular have been fully merged or fused with social practices of teachers and students, are their intellectual resources genuinely augmented and learning achievements correspondingly facilitated (Hakkarainen et al. 2004a). Our investigations, for more than a decade, indicate that meaningful technology-enhanced learning presupposes expansive learning (Engeström 1987) processes in which novel technology-mediated practices of learning and instruction are iteratively developed (Hakkarainen 2003b, c, 2004). Computer simulations, and other applications with a specific educational focus, which are assimilated as novel instruments of prevailing activity systems, may produce significant learning gains (e.g., De Jong and van Jooligen 1998). Yet profound transformation of social practices is called for in the context of community-oriented approaches of technology-enhanced learning, such as knowledge building, that aim at reorganizing classroom activities by following examples of scholarly communities. It appears that advancement of the field requires a more comprehensive understanding of the complex and dynamic relations between technologies and social practices involved in educational transformation processes.

Such *social practices* are assemblages of human activity that involve goal-directed sequences of actions using certain technology and rely on a socio-historically developed system of knowledge (Schatzki 2001, 2002; Scribner and Cole 1981). The participants have to develop capacities for pursuing coordinated actions that involve applying cultural knowledge in particular settings of their activity. Current theories of social practices highlight both the inseparability of knowing and doing and the creative and improvisational aspect of practice: "Far from being the locus of mechanical repetition and mindlessness, practice is instead a key to the comprehension of knowledge-related phenomena. It is in

practice, in fact, that knowledge comes to life, stays alive, and fades away. It is in practice that institutionalized, historically determined, and codified expertise acquires sense and becomes both a resource and a constraint for action" (Nicolini et al. 2004, p. 26).

By *knowledge practices*, in turn, I refer to personal and social practices related to working with knowledge. The term "knowledge" is used in the broadest sense, to include what is explicit or stated in official discourse (e.g., approved texts), to what is implicit, informing one's habits (perhaps pre-reflectively) of expert working; and further yet to that which underlies the competencies of experts, for example, so called "procedural knowledge." Knowledge practices, while sometimes just supporting routine learning (transmission), at their creative edge diverge from other routine social practices in that they take place in specific purposefully dynamic and fluid settings designed for the furtherance of innovation and knowledge. Rather than relying only on mere mundane habits or repeated routines (that may also be needed), such practices are aimed at solving emergent problems and constant pursuit of novelty and innovation. It may be argued that in the case of communities that follow such practices, innovation and pursuit of novelty are themselves transformed to shared social practices through the cultivation of corresponding personal and collective competencies and patterns of shared activity (Knorr-Cetina 1999, 2001). Whenever such innovative practices are encountered, we are dealing with *innovative knowledge communities* and their networks (Hakkarainen et al. 2004b, 2009). Rather than arising from mysterious personal gifts or creative talents, innovation and discovery rely on collectively cultivated epistemic practices that guide and channel the participants' intellectual efforts in creative and expansive ways (Hakkarainen et al. 2004a). A central characteristic of such activity is deliberate reinvention of prevailing practices (Knorr-Cetina 2001), systematic pursuit of novelty, and constant working at the edge of competence (Bereiter and Scardamalia 1993). While knowledge-building research indicates that such communities can be created even at the elementary-education level, neither the reliance of these communities on social practices nor their material embodiment have been properly addressed.

Knowledge-centered practices are mediated by epistemic technologies, that is, technologies that allow the participants to constantly remediate their activities by creating epistemic artifacts. Mediation based on collaborative technologies transforms students' intangible ideas into digital entities that can be further articulated, shared, interlinked, and extended in long-term processes. Deliberate efforts of transformation are facilitated by providing instruments and methods that allow making visible, reflecting on, and transforming prevailing practices. Knowledge-centered practices are accessible even to elementary school students because of material agency, based on reciprocal tuning of social, technical, and material aspects of activity, provided by these technologies (cf. Pickering 1995); knowledge advancement would not be possible without such technology mediation. The process focuses on developing shared epistemic objects of activity; these epistemic "things" (artifacts) are incomplete, knowledge-laden, yet materially embodied, objects that have a capacity, endlessly, to open up novel lines of inquiry (Knorr-Cetina 2001).

On the basis of these kinds of considerations, I am developing an object-centered—trialogical—approach to technology-mediated learning together with my colleagues. This approach relies on our research on three metaphors of learning, that is, the knowledge acquisition metaphor, participation metaphor, and knowledge-creation metaphor. The acquisition metaphor addresses assimilation of prevailing knowledge by individual learners highlighting the role of the individual's mental models or schemata in learning. The participation approach, in turn, focuses on social appropriation of community knowledge and adaptation to existing cultural practices, which may be called a "knowing" process (on

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the first two metaphors, see Sfard 1998; Lave and Wenger 1991). The acquisition approach and the participation approach, we have argued, have methods of dealing with innovation, but more fundamental reconception is needed. (Paavola et al. 2004). Q1

The theories of innovative knowledge communities are a basis for a third approach of learning aimed at overcoming the dichotomy between the acquisition and participation metaphors; we call it a *knowledge-creation* metaphor of learning (Paavola et al. 2004; Hakkarainen et al. 2004c). While the acquisition view represents a "monological" (subjective, mental) view on human learning and the participation view represents a "dialogical" (intersubjective) view, the knowledge-creation perspective may be understood as "trialogical" ("objective," Davidson 2001) in nature because of its foregrounding interaction between individuals, communities, *and shared knowledge-laden artifacts being developed*. The present approach is intended to examine practices and conceptualizations as dialectically related entities; this provides space for human agency that plays a crucial role in creative reflection and transformation of practices. Developing an object-centered view of human activity, characteristic of the trialogical approach, is a significant trend from philosophy (Davidson 2001; Clark 2003; Skagestad 1993; Sterelny 2004) to post-human social studies of science (Latour 1993, 2005; Knorr-Cetina 1999) and from organizational research (Engeström and Blackler 2005b; Law and Singleton 2005) to psychology (Donald 1991; Gruber 1981; Hakkarainen et al. 2004a).

Facilitating advanced inquiry cultures in elementary-level education

In what follows, we will examine and reflect on relations between knowledge building and the "trialogical" knowledge practice frameworks; we will set out some implications of our examination. Scardamalia and Bereiter (1991, 1994, 1999) have pursued groundbreaking research on technology-enhanced learning from the middle 80s on, and developed a series of technology-mediated learning environments, such as the Computer-Supported Intentional Learning Environments (CSILE) and its current version, Knowledge Forum. While pursuing my doctoral studies at the University of Toronto in the beginning of the 1990s, I was introduced to material produced by very young CSILE students. These elementary school students were apparently engaged in in-depth inquiry posing ingenious questions and elaborating, collaboratively, marvelous theories of their own. It was natural for me to become engaged in such a phenomenon and start pursuing a doctoral dissertation on the topic.

My doctoral dissertation, supervised by Bereiter, was entitled "Epistemology of Scientific Inquiry and Computer-supported Collaborative Learning" (Hakkarainen 1998). The study addressed 10- to 11-year-old students' research-like process of inquiry within a computer-supported collaborative-learning setting. The issue was to examine how these students, with scaffolds, engaged in the question- and explanation-driven inquiry characteristic of scientific research. The dissertation involved a series of studies over three years in which I qualitatively analyzed the epistemological nature of 10- to 11-year-old CSILE students' research questions and explanations. In a resulting publication (Hakkarainen 2003b), I reported that a mature, progressive-inquiry culture was taking shape in classroom A; only a minority of the students produced knowledge at a high explanatory level, but gradually this practice started to dominate the class. In Class B, an inquiry culture never emerged for reasons explored. Further, qualitative analyses of the epistemology of CSILE students' inquiry culture in classroom A indicated that knowledge produced by the CSILE class in question was at a very high explanatory level both in biology (Hakkarainen 2003c) and physics (Hakkarainen 2004). Practically all research questions posed by the participants were explanation-seeking in

nature. Moreover, the students pursued their research questions in depth, following the pattern of interrogative activity (Hakkarainen and Sintonen 2002): Initially very "big" questions and tentative working theories were set out; then participants proceeded to search for answers to a series of subordinate questions (Hintikka 1999), scaffolding them within CSILE. The analyses indicated that many of the students made considerable conceptual progress (Hakkarainen 2003b, 2004). Because the students' progress was assessed by examining their written productions, the evidence of conceptual progress was not conclusive.

Back in Finland in 1994, I started to pursue research on cognition and its support with computer technology, together with several students and colleagues. A surprising phenomenon emerged, however, after my colleagues and I started a CSILE project of our own. Initially, students taking part in their experiments did not rise to the intended level; they were pursuing only fact-seeking questions and producing only fragmentary knowledge (Hakkarainen et al. 2002; Lipponen and Hakkarainen 1997). In spite of the fact that the experiments not only took place in an ordinary school, but also in an elite one, students tended to do excessive copying of information. My collaborators and I spent a great deal of effort popularizing the theoretical foundations of knowledge building and engaged in repeated efforts to transmit the resulting insights to the practicing teachers (Hakkarainen et al. 1999; see also Hakkarainen et al. 2008). Although the conceptual problems were solved, the computer/software focus typically led to the teachers becoming more interested in ICT technology than learning or understanding. The puzzling phenomenon addressed in this article is as follows: *What were the invisible foundations of knowledge-building inquiry that we were not conveying to the teachers in question?* One might rephrase the question as, what are the general foundations of knowledge advancement, which might explain its successes and failures in various environments? This query pointed me toward participatory aspects of learning that had been invisible to many cognitive researchers: Learning takes place within *communities of practice* (Lave and Wegner 1991); these guide and constrain the participants' knowledge-advancing activities in a way that was not articulated by the knowledge-building approach. In order to understand the puzzling phenomenon—successes mixed with failures—we have to go back to reflecting on what knowledge building is all about.

Basic assumptions of the knowledge-building approach

By generalizing results of cognitive research on writing and expertise, Bereiter and Scardamalia (1987a, b) developed an ingenious pedagogical approach—knowledge-building theory—that guides students to work creatively with knowledge (Bereiter and Scardamalia 2003). Rather than assimilating information provided by a textbook, the participants of knowledge-building communities are guided to pursue their own research questions, follow them in depth, generate intuitive theories for understanding, and explain various issues relevant for their school education. The Copernican revolution of education is in putting students' ideas into the centre rather than periphery of educational activity (Scardamalia 1999).

Moreover, Bereiter (2002) has developed a sophisticated framework for conceptualizing the knowledge-building processes. One of the insightful moves that he has made was a distinction between learning and knowledge building. The former is focused on gains in individual knowledge and understanding whereas the latter represents collective advancement of knowledge. The knowledge-building process is focused on advancing entities that Bereiter (2002) calls *conceptual artifacts*. Just as ordinary tools are used for such practical purposes as hammering and drilling, conceptual artifacts can be used for epistemic purposes such as explanation and prediction. These artifacts are not in the minds of the participants

but occupy Popper's (1972) world of cultural knowledge. While the knowledge-building framework offered theoretical justification, the Knowledge Forum environment provided a transformative instrument that allowed even elementary school students to create their local world of cultural knowledge. The theory is very multifaceted, content-rich, and educationally inspiring; here, it is not possible to provide a comprehensive overview (but see Scardamalia and Bereiter 2006; Bereiter and Scardamalia 2003).

The argument of the present paper is that while knowledge building has made a valuable contribution for improving the quality of modern education, the theory does not in its current form provide a sufficient explanation for its own success, nor can it properly account for certain failures of implementation. The problem is that knowledge-building discourse focuses almost exclusively on ideas (see, for example, Scardamalia and Bereiter 2006): "a dynamic systems explanation of conceptual growth posits (along with other kinds of interactions) *ideas* interacting with *ideas* to generate new *ideas*" (p. 104, my emphasis). The above characterization appears, to some extent, to be tautological in nature. In order to overcome the tautology in question, we have to break the closed circle of ideas and make "the other kinds of interactions" the main object of inquiry rather than a side issue. Simultaneously, importance of systematic knowledge-advancement efforts, highlighted by Bereiter and Scardamalia, has to be acknowledged; when one realizes the constitutive role of social practices, it is not enough simply to accept or incorporate participatory approaches that reduce learning and intelligence to shared practices and social structures (Hakkarainen 2003b). The reason for starting to pursue the trialogical knowledge practices approach was a need to address epistemic processes—and their objects—involved in advancement of knowledge in parallel with social practices.

Bereiter's (2002) position concerning the role of ideas in knowledge creation is quite consistent. From elementary school classes to epistemic communities functioning at the frontiers of knowledge advancement, ideas are interpreted to represent the cornerstone of knowledge creation. Further, Bereiter is sensitive to the importance of externalizing ideas, for instance, in writing them down. His position appears to a great extent also to be educationally defensible; there is no doubt that focus on ideas generated by students, and the concrete expression of these ideas, is likely to improve the quality of education. If there were a series of practical activities in which idea improvement were not at all involved, one might well question whether an educationally valuable process of knowledge advancement took place at all. Ideas understood as conceptual artifacts do, indeed, function as carriers of what we will call *knowledge advancement*, a broad term meant to embrace conceptual and material aspects, and which subsumes "knowledge building." One can examine, as does Bereiter, an innovative product development or scientific inquiry process in terms of ideas being elaborated, given outward form, shared, extended, interlinked, and risen above the activity-processes in question. This line of reasoning has, of course, been the very foundation of traditional epistemology and the philosophy of science; it was not seriously challenged before the emergence of laboratory studies of scientific practices (e.g., Knorr-Cetina 1999; Latour and Woolgar 1986; Pickering 1995) that revealed the material aspect of—and "epistemic engineering" (Sterelny 2004) involved in—knowledge creation (Baird 2004; Clark 2003, see Hakkarainen 2003a for an analysis of the psychological implications of such studies).

Between conceptual and material aspect of artifacts

Nevertheless, I would like to argue that expanding the knowledge-building approach toward more fully accounting for material aspects of inquiry, as well as social practices,

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would facilitate advancement of this pedagogically valuable scientific research program. Although ideas understood as conceptual artifacts (Bereiter 2002) certainly play an important role in the *knowledge-advancement* process, broadly conceived, this is not the whole story; what is crucial is the bigger picture. Let us take another look at a knowledge-building classroom and reexamine what is going on; perhaps we can explain, more comprehensively, the situations of thriving and the situations of failure to advance; the situations where ideas show progress in knowledge advancements and where they do not. Here I rely on my extensive experience of both Canadian and Finnish knowledge-building classrooms. Let us assume that knowledge-building pedagogy is implemented in an elementary school at grade four level or so. Toward that end, the participants use a Knowledge Forum (Scardamalia and Bereiter 2006) environment that provides sophisticated tools for creatively externalizing students' ideas, storing them in a shared collaborative space in which the other students can comment on them, build on them, or rise above them. Navigation through a gradually accumulating knowledge network is assisted by interlinking and visually organizing the notes created.

The point that I wish to make is that something beyond mere collecting and organizing ideas is taking place. The way students work with ideas is different from ordinary oral discourse taking place in many classrooms because of the technology-enhanced learning environment transforming the intangible insights generated to digital form, and therefore, also, materially embodied ideas that exist outside of the participants' minds. This aspect of technology mediation has three dimensions.

First, the participants produce knowledge by writing about their ideas. Externalization allows them to transform fuzzy and vague ideas into shareable epistemic artifacts. In general, inquirers are not simply creating novel ideas by deriving new thoughts from earlier ones within their minds. In our *knowledge-creation* perspective (Paavola et al. 2004; Paavola and Hakkarainen 2005a), interaction between levels of knowing, and especially between conceptualization and practical activity is essential (Paavola and Hakkarainen 2005b). Knowledge creation has a three-fold character, which has led us to use the term "trialogical" (Paavola and Hakkarainen 2004): It not only involves symbolic processes (Thirdness, in Peirce) but also fuzzy and vague feelings (Firstness) and resistance encountered in practical experimentation (Secondness) that may, in turn, bring about new conceptualizations (Paavola and Hakkarainen 2005b). Novel ideas, as proposed by Peirce, emerge in a complex process, through interaction and transformations across these levels of knowing. This crucial point—the larger matrix, the systemic interactions—is not properly appreciated if lower level processes are primarily attended to (e.g., investigated); specifically, it is not sufficient for a rich, robust account, if ideas, even externally formed and elaborated, are the main focus of attention. To put it another way, the interaction of ideas only cannot provide a general account of their progress, if any, in knowledge advancement, or "knowledge building" in particular. We must look at another layer of causal factors.

Secondly, it is psychologically relevant that students are extending their thinking by working at the boundary-surface of the epistemic artifacts being generated. Many experts report that they generate novel ideas by systematically relying on epistemic practices augmented by systemic objectification or materialization of ideas on paper (Donald 1991; Skagestad 1993; Hakkarainen 2008). These knowledge-advancement efforts involving successive elaboration of ideas within mind and on paper take place in space and time. Popper's (1972) main focus on the conceptual content of ideas occupying World 3 does not do justice to the material basis of such epistemic practices, and this weakness, to some extent, is reflected in Bereiter's approach despite its being tempered by the latter's sense of the concrete practices of education. By contrast, let us consider Donald's (1991) analyses of transformations of the

architecture of human intelligent activity through evolution of corresponding external memory fields (EXMF). Following Vygotski (1978), it may be proposed that creation of epistemic artifacts remediates the participants' activities, by creating a second stimulus that assists in examining the subsequent ideas from a novel perspective (Engeström 2006, 2007). Without the external embodiment of the ideas, *double stimulation* would not work, and the effort does not lead to significant advancement. Rather than only two stimuli, there is a whole series of external stimuli—the material artifacts—within a knowledge-building environment created by the students themselves that assist in guiding inquiry from outside.

The third material aspect of the above-described knowledge practices is the technology mediation involved. Could the participants' inquiry succeed at all without the *material agency* (Pickering 1995) provided by the learning environment in question. To some extent, yes, but something very essential would be missing. Many lines of inquiry emerging during the self-organizing process would likely have been missing. It would have been impossible for the participants to pursue "longer trains of thought" (Darwin, see Gruber 1981) required for making real conceptual progress. The learning environment provided agency that carried the inquiry further ahead than would have otherwise been possible. It is true that paper and pencil techniques, and the printed page, which investigators have relied on for hundreds of years would provide some support; I would like to argue, however, that technology-mediated events played, in the present case, a critical role in augmenting inquiry processes in question. Trialogical activity cannot easily be taken part in without appropriate technologies that help the participants to create and share, elaborate and transform, organize and visually model diverse epistemic artifacts in conjunction with making visible, reflecting on, and transforming their knowledge practices. The Knowledge Forum type of environments appears to provide novel instruments needed for sustained working with elaborated, spatially and temporally expanded, and collectively distributed objects of activity (cf. Engeström et al. 2003).

The above examination supports our position that *genuine knowledge advancement is not just a conceptual process, but has a material basis as well*. The lack of inclusion of material artifacts in the causal analysis, greatly handicaps the effort to explain the situations of knowledge advancement or its lack. Intermixing of meaning and material evident in creation of digital artifacts is called *hybridization* (Latour 1993). It is a central characteristic of human activity that we crystallize our ideas and thoughts as "*epistemic things*" (Rheinberger 1997), that is, materially embodied knowledge-laden artifacts. I would argue that CSILE and Knowledge Forum are actually *children of hybridization* (see Paavola and Hakkarainen 2004) in providing material agency that allows the users to entertain more complex thought, engage in deeper inquiries, immerse in more intensive collaborative processes than would otherwise be possible at all (Seitamaa-Hakkarainen et al. 2004; Muukkonen and Lakkala this issue). Rather than addressing mere ideas, it would be essential to account for the evolution of heterogeneous networks of people, technologies, and physically embodied as well as mentally represented epistemic artifacts.

Cultivating knowledge-creating practices of learning in a classroom

Just like any other human-built artifact, Knowledge Forum may be seen to literally carry knowledge concerning inquiry processes. This knowledge is embedded in the design of structures and functions of the learning environment in question. In many cases, such instrumental, "thing" knowledge has been more important than the theories that are used to explain the instruments in question (Baird 2004). Knowledge Forum bears working knowledge

of inquiry processes; knowledge literally embodying an idea that hybridization is the key to *knowledge creation*, our term by which we emphasize the three-fold nature of the process. While knowledge-building theory talks mainly about ideas, the actual design of corresponding learning environments indicates the importance of intermixing meanings and materials.

In a series of investigations, we used Knowledge Forum for sharing experiences of various cultural activities, diverging substantially from conventional within-classroom inquiry processes. For example, we documented visually (background pictures) and conceptually (text notes) (a) encounters with experts, (b) results of field studies, (c) student-designed exhibition, and (d) design of concrete artifacts created by the students (Kangas et al. 2007; Seitamaa-Hakkarainen et al. 2004; Seitamaa-Hakkarainen et al. in press). The technology bends easily to elicit "hybrid" rather than hermetic (conceptually encapsulated) knowledge building. In the long run, the knowledge carried by the present, materially embodied instrument, which gives us reliable access to knowledge phenomena, might turn out to be more relevant than theories used to explain the phenomenon (cf. Baird 2004).

New technology-enhanced learning environments do not, however, automatically become instruments in teachers' and students' joint activities; as mentioned above, transformation of their social practices is also called for. The process of transforming an artifact into an instrument of human activity is a developmental process of its own (see Virkkunen and Ahonen 2007). Pierre Rabardel and his colleagues have examined the dynamics of such processes of "instrument genesis" (Vérillon and Rabardel 1995; Béguin and Rabardel 2000). The first stage of the process involves shaping, adapting, and tailoring the artifact according to the local needs and requirements of activity. A teacher who selects a technology-enhanced learning environment and designs, jointly with students (and researchers), knowledge-building projects to be pursued, has a critical role in this *instrumentation process*. The second stage focuses on developing and cultivating personal and collective practices needed for productively using the artifact as an instrument in knowledge-building activity. The gradual *instrumentalization* process takes time and depends on the involved agents' own intensive participation in the collective inquiry process. It involves a developmental process in which the instrument gradually merges or fuses in the participants' transforming activity system (Engeström 1987). Before developing social practices in which the use of an instrument is embedded, all of its affordances cannot be productively utilized. Such processes are also involved in educational communities engaged in pedagogical experiments of knowledge building. The following illustrates how I came to appreciate this point.

I observed that, in accordance with practically all approaches aimed at pedagogical innovation, successful knowledge-building cultures are usually based on single classes in which there is an exceptionally motivated and committed teacher. While annual knowledge-building workshops may allow teacher practitioners to share their knowledge-building experiences with researchers, such networking draws people and communities who are already involved in pursuing pedagogical transformations. Advancement of local knowledge-building communities is because the teacher iteratively works to transform local classroom practices toward inquiry-based ones, involving students' participation in collaborative knowledge building. By practically exploring various possibilities, getting rid of weaknesses, resolving tensions and disturbances, and promoting the desired characteristics, he or she is able to promote directed evolution of classroom practices. The process does not, of course, take place only in a top-down fashion from teachers' guidance to transformation of students' practices, but involves improvisational and dynamic coevolution between patterns of using shared instruments, trialogical objects pursued, and teachers' and students' activities. These kinds of cultures are typically restricted to single classes

because such a setup provides the teacher with control over many aspects of the learners' everyday practices. Interaction with researchers may assist in the process, but may not be necessary. The resulting inquiry culture is *radically local* (Michael Cole, personal communication) because it is not easily transferred even next door (cf. Hedegaard and Chaiklin 2005). My argument is that such invisible work of teacher-practitioners should be analyzed so as to make it the object of scientific scrutiny.

It is clear that we are again talking about social practices rather than mere ideas. Successful knowledge-building cultures rely on gradual cultivation of knowledge practices that channel the participants' epistemic efforts in a way that elicits knowledge advancement (Hewitt 1996; Hakkarainen 2003b, 2004). Of equal importance, we have come to see that social practices, *in other forms*, also dominate less successful classes, and help account for their limited advances. Many of the above examples presuppose that we have a competent teacher who is familiar with knowledge building and Knowledge Forum. That is not always the case. Whenever there is a mismatch between affordances provided by a technology-enhanced learning environment and the participants' actual activities, the process does not produce worthwhile results. When used in conjunction with traditional educational practices, the use of Knowledge Forum may actually lead to excessive copying of information (Lipponen and Hakkarainen 1997).

Creation of successful knowledge-building cultures is difficult because social practices cannot easily be changed or knowledge-centered innovation cultures elicited. Some researchers have failed sufficiently to appreciate this point. While belief revision is often easy, and students and teachers can easily come to believe that knowledge building, per se, is a pedagogically desirable activity, the corresponding transformation of social practices is difficult. Both students and the teacher have an experience-based and non-conscious *habitus* (Bourdieu 1977; Roth 2002) that determines their action potentials in many ways. It is easy to engage in activities that are in accordance with the habitus, but very difficult to do anything that substantially diverges from it. The participants feel themselves like fish outside of water whenever they do something radically different from their prevailing habitus. Consequently, efforts to transform classroom cultures face serious obstacles that need to be identified and articulated in order to go through successful change processes. Transformation of educational practices takes a relatively long time because social practices, and corresponding habitus of the participants, only transform very slowly. The co-teaching approach developed by Roth (2002) and his colleagues indicates the productiveness of making teachers and students aware of implicit effects of experience-based habitus on such epistemic activities as questioning and coaching students. Teacher-led deliberate reflection taking place in intersubjective interaction makes the participants able to gradually change their practices. Bourdieu's own writing may not fully do justice to transformative agency, both presupposed and cultivated by knowledge cultures, which involve creative troublemaking, intentional extension of practices to unanticipated directions, and often systematic and deliberate efforts to change practices toward ones better eliciting knowledge creation (Bohman 1999; Miettinen and Virkkunen 2006; Virkkunen 2006). It appears profitable to develop corresponding practices in the context of knowledge-building experiments.

An implicit theory of social practices is not sufficient

Investigators of technology-enhanced learning have recently addressed the role of social practices. For instance, Kolodner (2002) has been investigating activity-structures on which meaningful learning by design takes place. Bielaczyc (2006), in turn, has examined social

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infrastructures needed for making knowledge building work in school. Such efforts have, thus far, not been extensive enough and often appear isolated from theoretical discourse concerning social practices.

Nevertheless, it may be argued that while the knowledge-building approach does not have an explicit theory of social practices regarding corresponding pedagogical experiments, it has an implicit one. When Bereiter and Scardamalia (2006) talk about knowledge building, they are implicitly considering social practices. A great deal of their writings addresses phenomena related to educational practices. They highlight the importance of restructuring educational activities in a way that elicits pursuit of knowledge building rather than mere task-completion goals. After more that two decades of research efforts, they have an extremely rich body of data concerning knowledge-building processes from elementary to high school and higher education levels. Thinking about these issues has led me to conclude that "knowledge building is social practice" in terms of characterizing certain practices relevant for creative knowledge advancement.

Moreover, Scardamalia's (2002) knowledge-building principles (see http://lcp.cite.hku.hk/resources/KBSN/Q1/KB_Principle.html) may be considered as descriptions of essential social practices. These principles crystallize long-term investigations concerning how to facilitate student-driven inquiry with systematic pursuit of questions and intuitive theories, create classroom-learning communities in which each participants' contribution is valued and collectively built on and extended; how to facilitate meaningful and creative use of authoritative knowledge, establish cultures of constructive interaction and dynamic assessment. In such cultures, even the weakest students are encouraged to do their best, and, finally, to orient themselves to going constantly beyond their present level of understanding, and making knowledge building a way of life. While the principles appear as useful pedagogical tools and instruments that teachers and many researchers find inspiring, I would argue that these are not sufficient. Firstly, while the principles appear to function best as descriptive or normative characterizations of classroom practices, those do not constitute a systemic theory of social practices in general or educational practices in particular. Secondly, there are many (currently 12) principles, and it is not clear how they relate to one another. Thirdly, there is not enough theoretical foundation that would explain why we should adopt these rather than some other principles. Fourthly, all of the principles are defined in epistemic terms that leave the role of social practices unclear and vague; that is the missing third dynamism beyond socio-cognitive and technological ones. Fifthly, even with these principles, the knowledge-building approach provides very little information concerning how to go about analyzing and changing social practices.

Nevertheless, it is theoretically and methodologically relevant to notice that there are tight interlinkages between teacher-practitioners and founders of the knowledge-building approach. The ideas of knowledge building have not emerged from conceptual considerations alone; an intensive interaction between academic researchers and teacher-practitioners has been essential. Practicing teachers have appropriated knowledge-building pedagogy and stretched it in directions not always anticipated by Bereiter and Scardamalia. This, of course, is not to deny that, while analyzing and interpreting knowledge-building practices enacted in various classrooms, Bereiter and Scardamalia have extended the approach beyond its initial boundaries.

Deliberate transformation of knowledge practices

When social practices are taken seriously, it follows that educational processes are always mediated by such social and collective phenomena whether investigators are aware of it or

not; only transformation of social practices brings about genuine educational change. Researchers using cultural-historical activity theory (Engeström 1987, 1999), have applied sophisticated conceptual tools for investigating and transforming social practices. This approach examines learning as an object-oriented activity mediated by instruments and structured by a certain division of labor, interacting communities, and shared rules. Expansive learning is a process of going through transformation of social practices. In many cases, it begins by starting to question prevailing practices, exploring, and implementing changes (Engeström 1987, 1999, 2007).

In line with activity theory, I propose that spontaneously emerged, expansive learning processes are in the background of extraordinary inquiry cultures that knowledge-building investigators, including Bereiter, Scardamalia, and I, have reported. Expansive learning is at work when innovative teachers engage in efforts to improve the prevailing practices, implement changes that take the culture in the desired direction, systematically eliminate weaknesses, and develop methods of intellectually socializing new cohorts of students to the evolving cultures. The fruitfulness of my position, of course, would be shown in its ability, more generally to account for the cultures which thrive and those which do not.

Knowledge building, or, according to our term, *knowledge creation* is not, consequently, primarily to be understood as based on ideas, or their leading to new ideas. From an educational reformer's or an educational psychologist's point of view, it is about creating knowledge practices, that is epistemic practices of working with knowledge, channeling the participants' efforts in ways that elicit knowledge advancement, in which the development of ideas is one component. Knorr-Cetina (1999, 2001), similarly, has asserted that innovation and knowledge creation are about creation of social practices; rather than rigid routines or repeated procedures, such practices are focused on constant re-creating in a way that elicits successful pursuit of innovation.

Creation of innovative knowledge communities appears to rely on an integrated pursuit of advancement of epistemic artifacts and transformation of the prevailing social practices. Knowledge artifacts and knowledge practices constitute a dialectical unity. Engagement in knowledge-building inquiry appears to transform, in the same time span, the participants' personal and collective knowledge practices. In trialogical knowledge–creation pursuits, the participants are forced to go through various kinds of boundary-breaking processes, evident in innovative pedagogical experiments (Muukkonen and Lakkala this issue). When knowledge-creating learning is understood to be dependent of materially embodied practices rather that mere conceptual experiences, it follows that genuine facilitation of learning requires (a) engaging students in solving complex problems coming from outside of the educational institution (rather than focus on curriculum-related problems); (b) making students, in a concrete way, break boundaries between communities (so as to make different roles accessible to them and make them reflectively aware of their knowledge practices); (c) organize collaborative encounters between students and experts (so as to provide sustained opportunities for appropriating knowledge practices followed by the latter); (d) create projects with external stakeholders that engage students in genuine cultural activities (so as to provide experiences of solving vital community problems in terms of, for instance, taking part in a local environmental movement, cf. Roth and Barton 2004; Virkkunen 2006).

Feasibility of such boundary-breaking practices can be questioned—like that of any other knowledge-building effort. I would like to argue, however, that it would be desirable and feasible to implement one extensive knowledge-creation project every year from elementary to high school education. What is distinctive in the present proposal is that knowledge-building efforts should be radically, externally oriented rather than mainly

address curricular themes. In order to address tensions and challenges related to transitions between school, home, friends, and other aspects of cultural practices, we need to reorient our investigations in the line of Nespor (1997, xii): "Instead of treating the school as a container filled with teacher cultures, student subgroups, classroom instruction, and administrative micropolitics, I look at … school … as an intersection in social space, a knot in a web of practices that stretch into complex systems beginning and ending outside the school. Instead of looking at educational settings—school, classroom and so forth—as having clear boundaries and identifiable content, I look at them as extensive in space and time, fluid in form and content, as intersections of multiple networks shaping cities, communities, schools, pedagogies, and teacher and student practices." Participation in genuine cultural activities taking place outside of an educational institution appears as a productive way of promoting novelty and innovation.

Through participating in a rich web of cultural activities, students are often literally pushed or even kicked to surpass themselves, otherwise the knowledge-building process would not be successful. Long-standing efforts gradually change the participants' habitus in a way that provides new possibilities of action (Roth 2002). The end results of inquiry processes are not only the artifacts, but also the transformed personal and collective practices. Transformations often require deliberate efforts, so-called second-order work (Engeström 1987) involved in intentional efforts to improve prevailing practices. Cultural–historical activity theory provides valuable resources for analyzing and facilitating educational transformations. By carrying out change-laboratory interventions (Engeström et al. 2002), it is possible to engage teacher communities in deliberately managing transformation of the prevailing social practices. Such interventions imply that researchers collect data on everyday practices prevailing at school. They might interview teachers and students. Selected participants could be shadowed across their everyday activities so as to understand the spatial and temporal constraints of their activity. Such video data are used as mirror material for making tensions, rupture, and contradictions embedded in the practices visible to the teacher community in question (Engeström et al. 1996). Across a number of joint sessions, the participants become effectively more aware of their prevailing practices and may agree about a series of changes that they would like to implement in collaboration with researchers.

Methodological implications

The present arguments are not only theoretically relevant but have methodological implications as well. In human sciences, method, so to speak, creates the phenomenon (research object) of investigation. If self-report questionnaires, for instance, created psychological research on "learning orientations"; if video technique gave rise to microanalytic studies of small-group cognition; then we may argue that research on knowledge produced by students in the databases of collaborative technologies created the knowledge-building phenomenon. As Hoppe (2007, p. 5) argued, CSCL is a research field that, to a significant extent, creates its own research objects. The knowledge-building approach represented a significant advancement of learning research in that it addressed relatively extended, longitudinal processes of knowledge advancement overlooked by approaches focusing on mainly here-and-now interactions around computers.

Knowledge-building processes would neither have been visible nor analyzable (in terms of tangible knowledge artifacts) without the collaborative technologies employed. Research methods have, however, a danger of becoming reified if investigators become too

preoccupied with the data easily accessible to them. It appears to me that there have been too many knowledge-building studies (many of them carried out by my own research network) that have merely addressed the knowledge processes mediated by shared databases worked on and too few studies in which knowledge-advancement activities and actual classroom practices have been analyzed in parallel. The present knowledge-practice perspective on technology-enhanced learning pushes investigators to study, ethnographically, transformation of actual classroom practices in parallel to pursuing complex and challenging projects with a local knowledge-creation aspect.

Moreover, in order to investigate sustained processes of knowledge advancement, novel research instruments are needed as well. We are developing a so-called Contextual Activity Sampling System (CASS) based on the experience-sampling method (ESM, Hektner et al. 2007) and ecological momentary assessment (EMA, Reis and Gable 2000; Muukkonen et al. 2008). The idea is to use mobile phones for contextually and repeatedly sampling students' knowledge practices in their natural context. The specific focus of the study is to examine students' intellectual and emotional processes at personal and collective levels related to their trialogical (object-related) knowledge-advancement efforts. Although this is still a work-in-progress and currently addresses advanced knowledge practices taking place in higher education, it appears that such longitudinally and developmentally oriented event sampling provides one way of tracing the evolving cognitive trails (Cussins 1992) that students make while pursuing projects that break boundaries between educational and professional institutions and facilitate transformation of their knowledge practices.

Discussion

The argument of the present article is that knowledge-building theory has not fully analyzed or taken account of the social and cultural transformations involved in knowledge advancement, broadly understood, in educational contexts. In order to provide a general explanation, one needs to deliberately address social practices and correspondingly expand the scope of the knowledge-building theory. This is essential because so much effort of teachers and researchers goes into promoting educational transformations. To the extent that the participants are not aware of the existence and critical role of the social practices, they are likely to repeatedly "hit their heads against a wall."

The present examination indicates that there are many fine and insightful features of the knowledge-building approach as well as findings that should not be abandoned, but built on. It appears, however, that addressing—theoretically or methodologically—the role of social practices would assist in providing a deeper foundation for explaining and understanding more and less successful knowledge-building cultures in education. It would assist in socially and culturally contextualizing knowledge-building phenomena in a way that elicits advancement of inquiry. As a consequence of an unarticulated theory of social practices, there have not been sufficient attempts to systematically collect information about corresponding classroom processes within the knowledge-building tradition. Although our research is already under way, we are only beginning to have the data with which we will gain a deeper understanding and explanation of the role of social practices in pursuit of educational innovations.

The knowledge-practice perspective appears to have significant theoretical, methodological, and practical implications, which we have taken account of, in our latest research projects. From the trialogical perspective, learning is understood as a

process of innovative inquiry aimed at progressively expanding one's knowledge and skills based on previous knowledge and deliberately transforming social practices (Paavola and Hakkarainen 2004). Rather than addressing a collaborative knowledge-advancement effort (project) as its own sphere of activity, I understand it to be tightly coupled with evolving knowledge practices of the participants. Rather than eliciting inquiry learning and knowledge building within the prevailing institutional practices and predetermined curricular boundaries, we focus on setups, arrangements, and patterns of interaction which elicit cross-fertilization of knowledge practices between educational and professional communities. From a sociocultural perspective, it appears that an exclusive focus on ideas is an artifact that emerges from the unwarranted insulation of educational activity from the content-rich and multifaceted activities in which people take part in the outside world (Engeström 1987).

There is, however, much evidence to be gathered to demonstrate how the social-practice perspective transforms the overall picture. I maintain that it does, but there may be defensible counter arguments. One may focus on creating cultures in which design mode (Bereiter and Scardamalia 2003) focused on collaborative advancement of knowledge is highlighted and "improvable ideas" entertained, thus letting someone else worry about social practices. Nevertheless, it appears that disregarding social practices makes both success and failures of knowledge building difficult to understand. One needs to come up with a more unified framework that addresses idea improvement in conjunction with transformation of social practices. This has been the overall goal of our research program.

The limitations of the knowledge-building approach addressed may partially reflect the general propensity of educational and CSCL researchers to develop their "learning environments" without adequate societal or institution-related theoretical foundations (Engeström 2009). As a psychologist, I do not have any problem understanding the difficulties of cognitive researchers regarding conceptualizing and theorizing about societal issues; these researchers, according to Olson (2003), have often attempted to derive needs of educational reform from theories of individual learning. Following him, it may be asked whether the theories or the school are at fault when "schools refuse to change and when they ignore the research" (2007, p. 87). The focus of the knowledge-building approach has been the possibility of eliciting deliberate collective advancement of knowledge in education, and, thereby, explicitly moving from the individual to the collective level. Yet, over the course of the research program and associated practice, the change in focus was only partial; the theory does not in itself address institutional structures and practices, the transformation of which genuine educational transformation appears to require. As Olson (2007) strikingly pointed out, "Yet, even if an improved understanding of learners is possible, it is not clear that such knowledge, generated by the best research, will have an impact on the practicalities of schooling … Schooling is an institutional practice that has been shaped up to meet a number of social constraints, and it is willing to take on board only those initiatives that affect the achievements of their mandated goals, including higher scores on specified tests. And it is not clear that research, even that inspired by Bruner [or Bereiter, one might add], has the instrumental value of raising those scores" (p. 92). It should be noticed that there are no trivial solutions for the challenge of educational transformations, and, therefore, the knowledge-practice perspective cannot provide miraculous solutions. It is exactly because we take the challenges of institutional transformation of education seriously, that we have undertaken a close collaboration with Engeström and his colleagues in cultural–historical activity theory; together we are creating the joint Centre for Research on Activity, Development, and Learning (CRADLE).

Acknowledgements The present investigation emerged in the context of research and development of the Knowledge-Practices Laboratory (www.kp-lab.org, FP6-2004-IST-4, an integrated project 27490, 2006-2011) funded by the Information Society Technologies (IST) program of the European Community. A research grant provided by the Research Council of Culture and Society of the Academy of Finland for "Collective intelligence: How shared 'trialogical' knowledge practices augment human cognitive capabilities" (2008–2010, number 121207, PI Hakkarainen) also supported writing of the article. I would like to thank Carl Bereiter, Ritva Engeström, Yrjö Engeström, Kirsti Lonka, Reijo Miettinen, Sami Paavola, Marlene Scardamalia, Pirita Seitamaa-Hakkarainen, Jaakko Virkkunen, and Hal White for valuable comments concerning the issues addressed in the present article. The arguments and opinions provided are my own and do not necessarily correspond to those of the KP-Lab consortium or the funding agencies mentioned above.

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