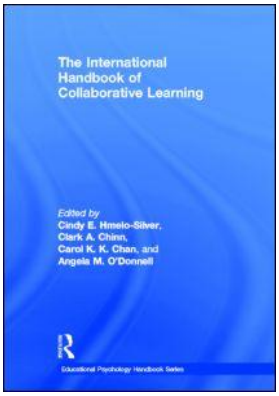

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SOCIOCULTURAL PERSPECTIVES ON COLLABORATIVE LEARNING

Toward Collaborative Knowledge Creation

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INTRODUCTION

The term *sociocultural approaches to learning* is quite widely used. It refers especially to approaches which have been influenced by L. S. Vygotsky's (1978) seminal work on understanding human development and learning. Vygotsky and his coworkers' texts, and later interpretations and developments (e.g., Cole, 1996; Engeström, 1987) have had a great influence on our understanding of human learning. Although sociocultural approaches are widely adopted, they still challenge many deeply rooted preconceptions of learning and human development. The basic locus of human learning is social interactions, cultural practices, and reciprocal personal and social transformations rather than individuals and individuals' minds. Within sociocultural approaches the meaning of language and semiotic mediation is often emphasized as a basis for understanding human activities.

In this chapter, we are *not* trying to give an overview of different ways of interpreting the sociocultural approach. Instead, we concisely analyze a distinction that we maintain cuts across many sociocultural approaches; that is, a distinction between approaches that emphasize participation and social interaction and those that emphasize collaborative knowledge creation. First we introduce the idea of three basic metaphors of learning; that is, as individualistically oriented acquisition, as participation, and as collaborative knowledge creation. Then we analyze some basic elements important for the knowledge creation approaches. Finally, we delineate a "trialogical" approach to learning which

focuses on those activities where people are organizing their work to develop shared artifacts and practices. While our approach emerges from studying technology mediated collaborative learning in institutional education, we maintain that it applies more generally to collaborative learning in a variety of settings, such as business and government entities devoted to research or development of products, processes, and technologies.

THREE APPROACHES TO COLLABORATIVE LEARNING

There appear to be three prominent approaches to learning within the domain of learning theories; the knowledge acquisition metaphor, the participation metaphor, and the knowledge creation metaphor. The *knowledge acquisition metaphor* examines knowledge as a property or characteristic of an individual mind (Sfard, 1998). The acquisition metaphor may be based on the traditional assumption of the transmission of knowledge to the student, or, as Sfard emphasizes, also an active and "constructive" (but individual) process. Acquisition approaches emphasize individual learning, but they can be applied also in collaborative learning (CL). CL is then interpreted as a peer-interactive process that facilitates (or sometimes hinders) an individual's personal learning, belief revision, and conceptual change by, for example, provoking cognitive conflicts (Mugny & Doise, 1978). Collaboration, however, does not in itself play a foundational role in this kind of learning although collaboration between individuals is an essential part of this type of approach. An alternative approach, according to Sfard (1998), is the *participation metaphor* for learning, which examines learning as a process of growing up and socializing in a community, and learning to function according to its socially negotiated norms (Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991). From the participatory perspective, learning is the process of growing to become a full member of a community, in which there gradually occurs a shift from peripheral to full participation. From this perspective, knowledge is not a thing in the world itself or within the mind of an individual, it is simply an aspect of cultural practices (Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991). Rather than the focus being, for example, on a body of knowledge in the traditional sense, the emphasis is on interaction, shared practices of meaning making (knowing), and learning from joint problem solving efforts. Collaborative activities involve intensive intersubjective interactions and shared meaning making (Stahl, 2006).

We maintain that besides these two metaphors, a third metaphor of learning is needed as a basis for theory and empirical investigation of collaborative learning. We call it the *knowledge creation metaphor* (Hakkarainen, Palonen, Paavola, & Lehtinen, 2004; Paavola, Lipponen, & Hakkarainen, 2004). This metaphor suggests, that despite clear differences, several theories of collaborative learning have a common aim of explicating collaborative processes involved in the creation or development of something new. As representative theorists of the knowledge creation metaphor, we ourselves have analyzed especially Bereiter's (2002) knowledge building, Engeström's (1987) expansive learning, and Nonaka and Takeuchi's (1995) organizational knowledge creation (Paavola et al., 2004). These theories have clear affinities with theories representing the participation metaphor of learning but still diverge from them in respect of being explicitly focused on addressing collaborative work for creating or developing novel things as a central aspect of collaborative learning. The knowledge creation metaphor is not meant to be a

specific theory of collaborative learning, but more like an umbrella term for otherwise quite different theories and approaches to collaborative learning. Many sociocultural approaches have elements both from the participation and the knowledge creation metaphor of learning.

A forerunner of knowledge creation is the theory of knowledge building, and we have ourselves tried to see connections between this theory (that emphasizes development of ideas together) and the cultural-historical activity theory (emphasizing collaboration around practical issues). Knowledge building is a pedagogical approach that is focused on transforming school classes to inquiry communities focused on improving their shared ideas understood as conceptual artifacts with the assistance of collaborative technologies (Scardamalia & Bereiter, 2006). While knowledge building clearly represents the knowledge creation metaphor it would benefit by being more anchored in social practices and material artifacts emphasized by activity theory and practice theories, which lie at the base of knowledge creation approaches. Activity theory builds on the idea that human activities are mediated by artifacts, used and modified by succeeding generations of human beings, and grounded in practical, everyday activities (Cole, 1996, pp. 108–110). Praxis and cultural artifacts are developed in interaction with one another in historically situated and evolving processes. Human activity, especially knowledge creation activities, is "object-oriented" (Engeström, 1987; Knorr Cetina, 2001) meaning that collaboration is organized around long-term efforts to develop shared, tangible objects, such as articles, models, and practices. It appears that activity theory could be advanced by a more comprehensive account of sustained epistemic mediation (i.e., work with various kinds of artifacts where knowledge is emphasized) involved in technology-mediated learning; collaborative learning entails that even elementary school children are engaged in deliberate construction of knowledge artifacts (texts, graphs, models, concepts, etc.) as psychological tools for remediating their activities (Vygotsky, 1978). Rather than being mainly guided to discuss and share their opinions of the issues and themes inquired, they are deliberately engaged in crystallizing, externalizing, sharing, and developing knowledge artifacts that embody their ideas (Scardamalia & Bereiter, 2006). We consider the three metaphors as heuristic tools that assist in examining various aspects of learning. If the knowledge acquisition metaphor is *monological* in nature in terms of within-mind processing of knowledge, and the participation metaphor highlights *dialogical* interaction, the knowledge creation metaphor is said to emphasize *trialogical* processes because it focuses on activities organized around systematic and deliberate pursuit of advancing shared "objects" (Paavola et al., 2004), with the understanding that the latter may be epistemic, not having tangible or material form.

A CASE EXAMPLE: LEARNING THROUGH COLLABORATIVE DESIGNING (LCD)

In this chapter our discussion of the knowledge creation approach to collaborative learning is organized around an empirical case regarding the learning by collaborative design (LCD) model. Collaborative designing appears by definition to be a knowledge creation process that involves joint efforts in creating design artifacts. Such a process involves students actively communicating and working together to create a shared view of their design ideas, make joint design decisions, construct and modify their design solutions,

and evaluate their outcomes through discourse (Hennessy & Murphy, 1999). Fostering learning through collaboration requires teachers or tutors to design, enact, and evaluate a specific kind of teaching and learning setting, paying attention to the nature of the design task, its context, and supportive pedagogy (Viilo, Seitamaa-Hakkarainen, & Hakkarainen, 2011). Successful collaboration is based on open-ended and authentic design tasks that allow students to confront the multidisciplinary or user-centered characteristics of design practice. The present investigators have investigated design processes from elementary-level education (e.g., design of lamps) and higher education (e.g., design of clothing for premature babies) to the professional level (design of various industrial products).

Seitamaa-Hakkarainen and her colleagues (Kangas, Seitamaa-Hakkarainen, & Hakkarainen, 2007; Seitamaa-Hakkarainen, Viilo, & Hakkarainen, 2010) have developed the learning by collaborative designing model, which highlights collaborative interaction among teams of students and between students and teachers or external domain experts in the design field. It examines the design process as a cyclical and iterative process in which workable solutions arise from a complex interaction between conceptualization, sketching, construction of materially embodied artifacts, explorations in which design constraints and ideas are revised and elaborated. The model illustrates relations between the following elements of the design process: (a) creation of the design context; (b) definition of the design task and related design constraints; (c) creation of conceptual and visual (physical) design ideas; (d) evaluation of design ideas and constraints, (e) experimentation with and testing of design ideas by sketching, modeling, and prototyping; (f) evaluation of prototype functions; and (g) elaboration of design ideas and redesigning. However, these phases should not be understood as a prescription for a rigidly specified sequence of design stages. The model merely illustrates the relations between elements of the collaborative design process (see Figure 3.1).

In settings where collaborative design learning takes place, the design context and the design task are defined through joint analysis; all participants have to learn to understand the external and internal constraints related to the problem or solution. In this phase, the teacher or external domain experts have the important task of helping students to define the diverse cultural, social, psychological, functional, and emotional aspects essential to the design of the product. There may well be conflicting issues that have an effect on the design process and its requirements that will need to be taken into consideration during the outlining of the design constraints. The design process moves forward cyclically by means of the acquisition of deepening knowledge, the sharing of that knowledge in a social context, production of varying design ideas, and evaluation of those ideas. Thus, constant cycles of idea generation, and testing of design ideas by visual modeling or prototyping, characterize the LCD process. Moreover, the critical role of the teacher or the external domain experts underscores the value of the physical context (i.e., diversity of concrete objects or material artifacts, interaction with tools) and social interaction in order to make design tasks shareable.

In what follows we will introduce an elementary level students' collaborative design project: the Artifact project. The project was designed together with the classroom teacher and took place in her classroom in Laajasalo Elementary School, Helsinki, Finland. It was based on the following ideas: (a) intensive collaboration between the teacher and researchers; (b) engagement of teams of students in design practices by collaborating with a professional design expert; (c) integration of many school subjects, such as

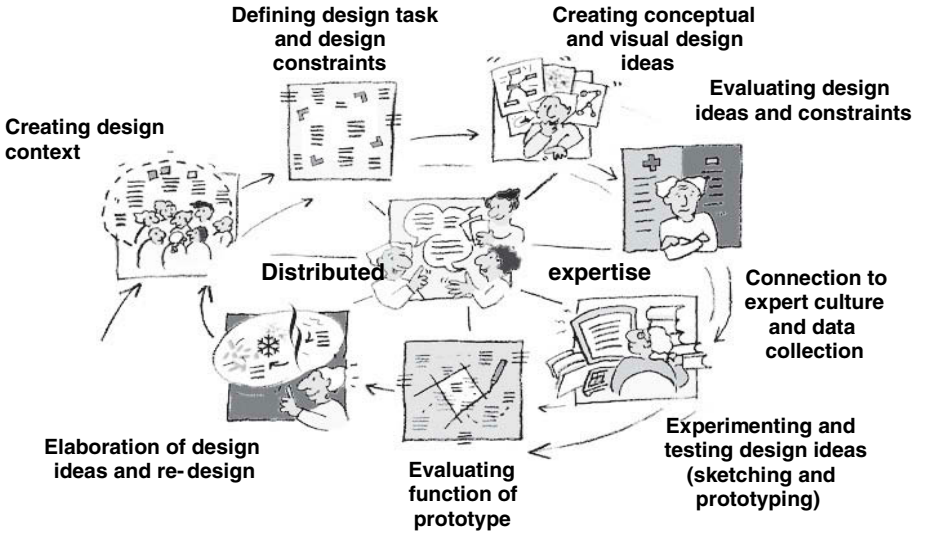


Figure 3.1 Learning by collaborative designing (LCD) model.

history, mother tongue, physics, chemistry, biology and geography, visual arts, technology, and craft education, for solving complex real-world problems; and (d) pursuit of collaborative design across an extended period of time. The Artifact project started with 31 elementary school students at the beginning of their second term of fourth grade and continued across 13 months until the end of fifth grade. Altogether, the Artifact project took 139 lessons (in Finland one lesson lasts 45 minutes) across three terms. The project highlighted the authentic design problems and the variety of conceptual and material aspects involved in design. The technical infrastructure of the project was provided by Knowledge Forum (KF; Scardamalia & Bereiter, 2006) and was designed to facilitate collaborative knowledge building. The phases of the project, their duration and main content, as well as the number of KF notes produced are presented in Figure 3.2. During the project, the students analyzed artifacts within their historical context, studied physical phenomena related to artifacts, examined designs of present-day artifacts, and finally designed artifacts for the future.

In the first phase of the Artifact project, The Past**,** an exploration of historical artifacts was conducted by looking into the evolution of artifacts as cultural entities. The item had to (a) be used daily, (b) have a long history, (c) originally be made by hand, and (d) be used by hand. Students chose items which most of them had used and which they found interesting: a clock, a spoon, money, a lock and a key, a jewel, a ball, and a flashlight. The students decided to research the historical aspects of the artifacts by visiting the Finnish National Museum, gathering offline and online reading materials, and interviewing grandparents.

- In the second phase of the project, The Present, the physical subject domains from the curriculum were integrated to the project. The teacher guided the students to investigate and ask research questions regarding the phenomena related to the chosen artifacts. The students planned, conducted, and reported their own experiments, or used ready-made tool kits to conduct expert-designed science experi-

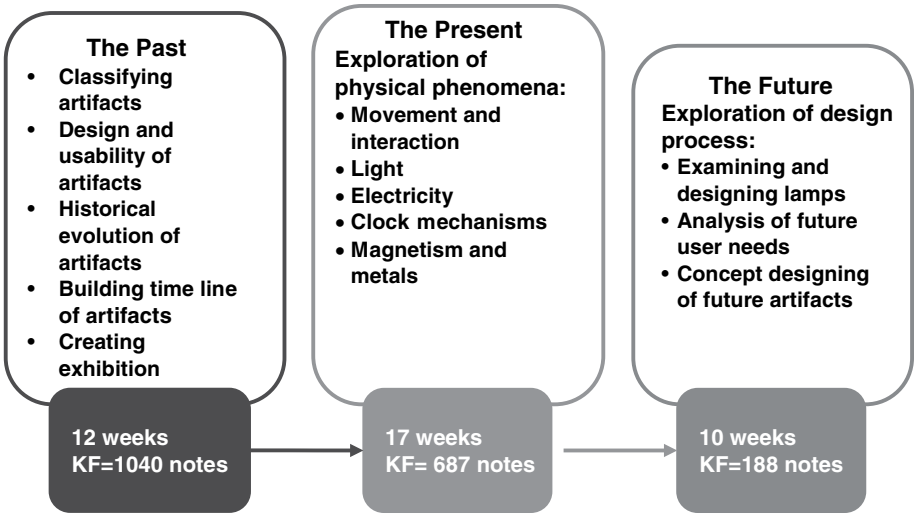


Figure 3.2 The phases of the Artifact project.

ments. In addition, the teacher arranged visits to a blacksmith's shop and the Clock Museum.

- The third phase of the project, The Future, addressed the designing of artifacts. First, the design process was rehearsed by designing a lamp. The leadership for this phase was provided by a professional designer together with the teacher. Beyond conceptual design relying on writing, the students supported their design through sketching and prototyping. The investigation of the present-day lamps design led the students toward the last stage of the project which was focused on projecting, in terms of design, how their chosen artifacts would look in the year 2020 (for a detailed description of the project, see Kangas et al., 2007; Seitamaa-Hakkarainen et al., 2010).

We now outline four aspects that we see as being central to the knowledge creation approach to collaborative learning: (a) CL is an object oriented process taking place across long periods of time, (b) the subject of CL is an inquiry community, (c) CL is mediated by collaborative technologies, (d) CL is a matter of expansive transformation of shared knowledge practices.

OBJECT-CENTERED APPROACH TO COLLABORATIVE LEARNING

According to the knowledge creation perspective, collaborative learning, particularly where innovation is involved, cannot be properly understood without addressing knowledge objects (i.e., symbolic-material artifacts, such as questions and theories, or practices) that are created, elaborated, advanced, built on, and which arise during the process. Instead of focusing on narrow textbook problems and transmission of predetermined rules and procedures, successful CL projects engage a learning community in a challenging series of inquiry objectives, such as building knowledge of natural or societal phenomena and designing artifacts, and induce students to commit to sustained efforts in attaining them. Independently finding solutions to complex problems is the

only known way of preparing students to solve unanticipated problems encountered in the future (Marton & Trigwell, 2000). From the activity-theoretical perspective, such an approach may bring about spatial and temporal expansion of the object of educational activity in terms of working with objects across multiple lessons, diverse contexts, and extended periods of time (Engeström, Puonti, & Seppänen, 2003).

The knowledge creation approaches guide educators to engage students in collaborative pursuit of varying complex and multifaceted problems that often come from outside of educational institutions and, thereby, break the epistemic boundaries of school learning. In the case of the Artifact project, these objectives were related to understanding the historical evolution of cultural artifacts, scientific principles of designing these kinds of artifacts, and the actual design process of novel artifacts. Common awareness about the shared assignment of the learning community can be promoted with the help of classroom discussions. In collaborative classes, the students regularly work in groups, and joint inquiry can be supported by a shared screen that is projected on the wall (a blackboard, posters, or a smart board could be used as well), in which shared works can be presented and pondered and which assists in sharing the research results of all student teams; this was, indeed, a central aspect of the pedagogical practices of the class teacher who organized the Artifact project (Viilo et al., 2011). Joint discussions in front of the shared screen may be supported by a networked learning (software-based) environment, such as Knowledge Forum (Scardamalia & Bereiter, 2006). Such environments provide a shared database for which the participants may produce knowledge.

Although the nature of knowledge objects cannot be fully determined before inquiry, and emerge from the collaborative process (Sawyer, 2005), their basic size and shape is usually known. As we see it, the objects of CL can be concrete (yet nonmaterial) artifacts that can be manipulated, shared, extended, and transformed. Such objects may come in multiple forms. Such objects involve *conceptual artifacts* or ideas (Bereiter, 2002), such as questions, hypotheses, and working theories as well as plans and conceptual designs. The processes of creating epistemic artifacts by writing, visualization, or prototyping may be called *epistemic mediation*. Such processes allow remediating one's activity by externalization and materialization of inquiry processes to shareable knowledge artifacts. Remediation even involves ideas and conceptions that have to be externalized and materialized so as to be shared and jointly developed. In design activity, students are concerned with the usefulness, adequacy, improvability, and developmental potential of ideas (Scardamalia & Bereiter, 2006). It is essential to provide students with experiences of solving complex design tasks that engage them in iterative improvement of their ideas and the artifacts embodying them.

In the context of the Artifact project, the objects that the participants were working with were shared problems and design tasks. Students' sketches, from the first drafts of ideas and general visualizations to construction details, played an essential role in the design process. Through this externalization, ideas became visible and improvable, enabling their collaborative advancement. With Knowledge Forum, students developed knowledge and skills to model, design, and construct ideas into physical artifacts through interactive process. For example, the professional designer described his own design process and drew students' attention to the essential points of flashlight design. The students were given the task of picking a well or badly designed flashlight from their own environment and presenting an analysis of that particular flashlight to the whole class. The analyses were also saved in the Knowledge Forum database (Figure 3.3):

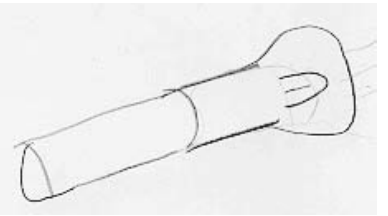
Presentation (student A): Flashlight	Presentation (student B): Flashlight
My flashlight lights up a relatively small part of the darkness, but you can point it where you like. The light is quite bright, but bad quality. It didn't cost very much. A flashlight can be carried easily anywhere. I think it's handmade.  *Good things are*: • covered with wood • can be carried easily • rather affordable • exclusive *Bad:* • bad quality of light • lights up a small spotbox ends	The bad thing about flashlights is the fact that the batteries will come to an end at some point.  *Good things are:* • you can direct it where ever you want to • lights up short or long distances • can be carried with you

Figure 3.3

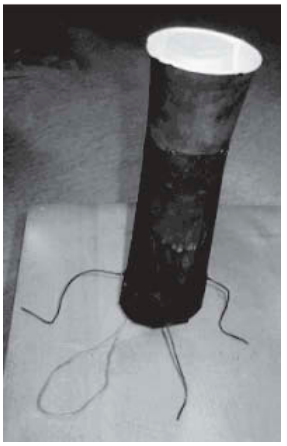
After the analysis of existing flashlights, these two students started to design collaboratively and stated their aim to improve the flashlight in the following way:

> *New flashlight*: The flashlight could be improved by adding 2 batteries, so the power would last longer. It would still be easy to carry. It would be easy to point it anywhere. Main measurements: 16 cm × 3 cm. Carrying tape at one end (#1833).

The designer commented on the students' notes by writing annotations:

> Are there any other options than adding batteries, to prevent the power from ending? What shape of flashlight would be the easiest to use? Do we need other than focused light from a flashlight? (#1903)

It was crucial for the students to understand the important constraints and specific features of a flashlight, such as the functional nature of the particular type of flashlight, in order to improve their preliminary design. They produced a variety of conceptual and visual design ideas (for example, replacing the batteries with an accumulator, and adding folding legs in order to keep the flashlight standing in a vertical position) leading to a final presentation and evaluation of the new flashlight (Figure 3.4).



Conclusions: We designed "The Calamar" on the basis of the flashlight. We wanted the flashlight to have soles. The goals were attained. There were no problems. The flashlight is a bit too large, but still it fits in a backpack, for instance. The carrying tape is not needed, otherwise it's all right. "The Calamar" is a good flashlight for expeditions or use at home. Basic measurements: 16 × 3 cm.

Figure 3.4 Conclusions on the design process of a flashlight (student team's KF note #2047).

Rather than seeing objects only as conceptual ideas, those undertaking a knowledge creation approach examine them as *hybrids* (Latour, 1999), being both knowledge-laden and physically embodied as digital or other types of artifacts. The role of materials and artifacts in the design process is crucial. Designers are "working with things"; they express their ideas in "things themselves" rather than merely words (Baird, 2004, pp. 148–149); in a literal sense, designed artifacts carry and embody knowledge. In order to understand and improve the ideas being developed, they have to be given a material form by means of practical exploration, prototyping, and making. Learning to work with *thing knowledge* involved, for instance, in modeling and prototyping, is an essential aspect of appropriating design practices (Baird, 2004). The Artifact project was explicitly oriented toward parallel working with conceptual and materially embodied artifacts. Concrete materials and tools, as well as testing with models and prototypes, supported the development of ideas by adding the material aspect to the conceptual ideas. Students thought with different materials during the design activity; they formulated ideas with the help of tools and machines mediating the meaning making process. Consequently, in design settings, material artifacts and tools have a central role in mediating the learning processes.

CREATING KNOWLEDGE COMMUNITIES FOR SUPPORTING COLLABORATIVE LEARNING

In order to elicit knowledge creation processes, it is essential to build an inquiry community that structures and directs the participants' collaborative epistemic activities. Collaborative inquiry learning appears to represent a special kind of cultural practice that can be appropriated by learners through organizing classrooms as inquiry communities (Brown, Ash, et al., 1993; Scardamalia & Bereiter, 2006). Ann L. Brown's distributed expertise and Scardamalia and Bereiter's knowledge building community focus on transforming classrooms into collaborative learning communities through facilitating the same types of social processes, such as public construction of knowledge, that characterize progressive research communities. The community of practice approach (Lave

& Wenger, 1991) and Engeström's (1987) expansive learning framework, in turn, focus on integrating school learning with authentic cultural activities taking place in the surrounding society. All of these approaches are relevant from the knowledge creation perspective, because each of them underscores the importance of community building.

Brown and her colleagues' (1993) distributed expertise approach relies on an assumption that collaborative learning requires the creation of a shared object for working and the setting of distributed tasks which support it. This approach highlights the importance of organizing students to work in heterogeneous teams so as to capitalize on their complementary knowledge and expertise and jointly achieve higher level collaborative objectives. Such pedagogy was utilized in the Artifact project. In the first phase of the project, the students worked in "home teams" (about 4 students per group), which investigated chosen artifacts specific to each group and produced knowledge to the team views of KF. In order to capitalize on complementary knowledge and expertise, the teams were heterogeneous, consisting of boys and girls, as well as less and more advanced students. Distributed regulation of inquiry involves the teacher, students, or specifically nominated team members following and assessing advancement of CL and providing encouragement and guidance when necessary; CL does not produce good results without such metalevel activity. Distributing expertise does not always produce the best results; consequently there is reason, once in a while, for the whole CL community to study some particular problem or subject domain (Hakkarainen et al., 2004). In this case, the thematic groups temporarily suspend their activities and everyone focuses on solving a single group's problem or challenge. Accordingly, the composition of the home teams of the Artifact project was changed when the investigations concerning artifacts of the present time, began. During this phase, all students were asked to work with the same topics and created Knowledge Forum views collectively shared by the whole class. This method allowed everyone to be brought up to the same level of knowledge required by the distribution of expertise; this way helps the whole learning community work at the same pace. In the last phase, the student teams were formed on the basis of their presentations of existing lighting solutions: Teams that presented table lamps, formed table lamp teams; teams that presented pendant lamp, formed pendant teams, and so on. For the designing of future artifacts, the students returned to their original home teams that had been formed at the beginning of the project (Kangas et al., 2007; Seitamaa-Hakkarainen et al., 2010).

Socioemotional processes also play an important role in CL focused on collective creation of knowledge. The participants (students and the teacher) have to be willing to take the risk of jumping into the unknown and engaging in improvisational efforts in the pursuit of new ideas. Students may be afraid of unavoidable mistakes and fear failure in front of their peers if a very competitive culture prevails within a classroom; this is likely to hinder and constrain their participation in CL. The teacher and researchers put a great deal of effort into creating an encouraging atmosphere in the classroom community that is carrying out the Artifact project and developed practices of constructive feedback. This effort is important because there are big differences between students' cognitive capacities due to the heterogeneous cultural, social, linguistic, and financial resources of their families in which cognitive growth and intellectual socialization take place. Constant assessment and competitive relative grading are likely to empower high achieving students and make other students feel inferior and perform less than optimally. The knowledge of students coming from socioeconomically advantaged homes

is often recognized by prevailing educational practices, whereas the knowledge and competence of the others is disregarded or underestimated (Roth & Barton, 2004). During the Artifact project, a number of students with special educational needs were successfully integrated into knowledge creating learning. It is beneficial to work in heterogeneous groups consisting of participants representing various levels of educational achievement and providing multiple zones of proximal development. Collaborative inquiry provides social structures that channel educational activity in a way that also engages disadvantaged students in more intensive meaningful learning efforts than otherwise would be the case. When working as a team, pursuit of challenging epistemic objects becomes attainable. Comprehensive supporting structures for eliciting focused inquiry, and the construction of a presentation or research reports are likely to assist in focusing on meaningful epistemic activities. A crucial role in classroom learning communities in general, and supporting disadvantaged students' learning in particular, is played by the teacher who, together with students, sets up higher-level inquiry objectives and shared milestones in negotiation with students, closely follows students' advancement, and directly instructs students when necessary. Overall, it is essential to allow students to build on their strengths, provide many paths to common educational objectives, and tailor pedagogical and rehabilitation efforts according to specific student characteristics; that is, what he or she knows and does not know, understands and does not understand (Clay, 1998; Olson, 2003).

Breaking boundaries between educational institutions and the surrounding society and providing experiences of taking part in genuine communities, networks, and social movements outside of school may provide experiences of CL and assist students in overcoming learning difficulties. The rationale of engaging students in collaborative designing in the context of the Artifact project was to cross-fertilize educational practices with those of professional designers. For example, the students were repeatedly asked to present their ongoing lamp design processes to the whole class, as professional designers present their ideas to clients. Situating the emerging ideas subject to collective evaluation, using expert practices and language, encouraged the students to reflect on and justify their ideas and make their reasoning clear. In addition, listening to other students' presentations helped in developing collaboration skills, such as turn-taking, listening, and respect for others' opinions. Roth and Barton (2004) have developed a novel approach to science education that involves engaging school children in actual collaboration with various external communities rather than merely simulating such activities. They argued that we need to rethink scientific literacy as involving the capacity to take a productive part in solving the strategic challenges of our time, such as protection of the environment and survival of the Earth. Roth and his colleagues have pursued a project during which students take part in protecting local waterways in collaboration with First Nation communities of British Colombia, Canada. Accordingly, students take part in collecting and analyzing samples, improving river banks, and reporting results in meetings of local environmental activists. Many students who do not show any visible promise within a school class, start to shine and produce sparkling ideas when engaged in a completely different type of educational activity that is involved in social movements (Roth & Barton, 2004); this observation also characterizes our experiences of the Artifact project. Expanding focus from classroom learning to authentic cultural activities appears essential for deepening CL approaches. Educational researchers have used the concept of "community" in a very shallow way, frequently without any deeper

theoretical foundations whatsoever; for example, they have assumed that classrooms as such constitute learning communities; whatever group of agents (e.g., students) that was brought together for a short time was considered to represent a community (Roth & Lee, 2006). In order to be considered a community of learning, a group of students needs to have a shared object of activity. While this is likely to be the case in the most innovative pedagogical experiments involving iterative cultivation of classroom practices across extended periods, it is something that has to be shown, case by case.

TECHNOLOGY-MEDIATION OF COLLABORATIVE LEARNING

What is the specific role of computer technology in knowledge-creating approaches to collaborative learning? As indicated by the very term, *information and communication technologies* (ICTs) have for a long time emphasized either the information genre or communication genre with monologues and dialogues as respective social activities (Enyedy & Hoadley, 2006). The main uses have been either to deliver knowledge and provide access to learning materials or open up networking and communication possibilities, instead of deliberately facilitating collaborative advancement of epistemic artifacts. It appears that knowledge creating practices have become available for educational institutions because of new technologies specifically designed to facilitate shared knowledge advancement. Bereiter's (2002) theory of knowledge building emerged from efforts to conceptualize computer-supported collaborative learning practices, mediated by Knowledge Forum, a specially designed environment for knowledge building that could not be understood in terms of mere individual learning. The success stories of Wikipedia and open-source development communities give reason to believe that new technologies play a crucial role in facilitating collaborative knowledge creation. Knowledge creation typically relies on support provided by collaborative technologies involved in transforming participants' ideas to shareable digital and yet material artifacts with which participants can interact. This makes it feasible for elementary school students to collectively work with objects that extend across space and time and heterogeneous networks of people and artifacts. These tools also allow the participants to record and capture many aspects of their inquiry processes for subsequent reflection. Rather than relying only on here-and-now oral discourse, a technology-enhanced shared space mediates the participants' activity and assists in externalizing, recording, and visually organizing all aspects and stages of their inquiry process (question generation, theory formation, prototype designing, and so on).

Accordingly, knowledge creating learning is supported by flexible technology mediation designed to scaffold long-standing collaborative efforts of creating and sharing as well as elaborating and transforming knowledge artifacts (Muukkonen, Lakkala, & Hakkarainen, 2005). In the Artifact project, we used Knowledge Forum for sharing the collaborative design process. Toward that end, the participants documented, visually (drawings and photos in the background of views and within the notes) and conceptually (text notes), (a) encounters with experts, (b) results of field studies, (c) student-designed exhibitions, and (d) design of concrete artifacts created by the students (Kangas et al., 2007; Seitamaa-Hakkarainen at al., 2010). Our experiences indicate that KF can be productively used to facilitate a materially embodied ("hybrid") design process in addition to conceptual design.

It appears that the technology as such does not determine the nature of its implementation but coevolves with gradually transforming institutional practices. 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 the participants' intellectual resources genuinely augmented and learning achievements correspondingly facilitated. Appropriating technology as an instrument of personal and collective activity is a developmental process of its own (Beguin & Rabardel, 2000; Jaakko Virkkunen, personal communication). For the success of the Artifact project, it was crucial that the teacher had sophisticated ICT competences, had cultivated practices and methods of using collaborative technology, and as well guided her students to use ICTs and KF. This is our evidence that technology enhances learning only through transformed social practices (Hakkarainen, 2009). Meaningful technology-enhanced learning presupposes expansive learning processes (Engeström, 1987) in which novel technology-mediated practices of learning and instruction are iteratively developed. In the context of CL, profound transformation of social practices is called for that reorganizes classroom activities along the lines of those followed by scholarly communities. 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.

COLLABORATIVE LEARNING RELIES ON DELIBERATELY CULTIVATED KNOWLEDGE PRACTICES

Establishing an educational learning community is essential because it carries or bears social structures and practices critical for knowledge creating approaches to collaborative learning. In order to make CL to work, it is essential to create and cultivate shared knowledge practices that guide participants' activities in a way that elicits a pursuit of shared inquiry. The term *knowledge practices* is used by the present investigators to refer to personal and social practices related to epistemic activities that include creating, sharing, and elaborating epistemic artifacts, such as written texts (Hakkarainen, 2009). Such practices refer to relatively stable but dynamically evolving shared routines and established procedures, such as question generation, explication of working theories, search for information, and contributing notes to KF, which have deliberately been cultivated within a learning community. Knowledge practices show a range from rigid routines and habitual procedures to deliberate and constant pursuit of novelties.

One basic tenet of the knowledge creation approach to collaborative learning is that innovation and pursuit of novelty are special kinds of social practices cultivated in epistemic communities and their networks (Hakkarainen et al., 2004; Knorr Cetina, 2001). A successful learning community deliberately aims at "reinventing" prevailing practices so as to elicit knowledge-creating inquiry (Knorr Cetina, 2001, p. 178). Innovative CL cultures cannot be created from scratch; this requires sustained iterative efforts in transforming social practices prevailing within classrooms toward more innovative ones. This transformation is something that advanced teachers have spontaneously engaged in; all successful cultures of collaborative learning capitalize on long-standing efforts to elicit directed evolution of prevailing knowledge practices in a way that advances inquiry. It appears to the present investigators that CL cultures necessarily rely on *expansive*

learning cultures (Engeström, 1987); that is, the creation of a local community by teachers, researchers, and students' efforts that deliberately reflects on and problematizes its prevailing practices, envisions and undergoes hands-on exploration of novel practices, and gradually consolidates those aspects of practices that appear productive. By using practical methods to explore various possibilities, getting rid of weaknesses, resolving tensions and disturbances, and promoting the desired characteristics, the teachers are able to promote directed evolution of classroom practices.

Consequently, directing of a CL does not only take place in a top-down fashion from teachers' guidance to redirection of students' activity, but involves reciprocal and improvisational efforts of making sense of the situation and finding productive lines of further inquiry. This process may be facilitated by engaging the students themselves in reflecting on and redesigning their practices. One of the teachers we are collaborating with has established a practice of, once in a while, bringing all activities in a classroom to a halt, and then asking all students to reflect on advancement of the overall project and jointly decide how to continue (Viilo et al., 2011). In the context of the Artifact project, the students were accustomed to design language in their interaction with the professional designer. He used authentic design terminology that was in many cases naturally adopted by the students in the course of their design work. Then again, the designer also appropriated some of the discursive practices of classrooms. He adopted epistemic practices of investigative learning by requesting students to explicate their design ideas and pushing them to undertake an in-depth inquiry. This process shows how successful CL cultures rely on gradual cultivation of knowledge practices that channel the participants' epistemic efforts toward knowledge advancement (Hakkarainen, 2009).

A new teacher should not become discouraged if collaborative learning does not immediately provide expected results. While it may be difficult to change an already established community's study practices, it is possible to intellectually socialize new student cohorts to advanced collaborative inquiry practices from the very beginning of their classroom studies (Hakkarainen, 2009; Hewitt, 1996). Through directed evolution of practices, a very advanced inquiry culture can be cultivated to which new cohorts of students can be socialized without repeating the initiators of the culture's developmental processes. It is advisable to engage in multiprofessional work with other teachers to create networks of classroom learning communities as well as promote corresponding transformation at the level of the whole school. This project implies overcoming spatial and temporary constraints on prevailing activities by multiprofessional collaboration between teachers, integration of instructional efforts initially fragmented according to disciplines, and boundary crossing between the school and the surrounding community (Engeström, Engeström, & Suntio, 2002); these means are crucially facilitated by the technology and learning environments. When integrated with iterative efforts to improve and develop the community by overcoming challenges and tensions encountered in classroom practices, it is possible to get into an expansive developmental trajectory of prevailing knowledge practices.

DISCUSSION

In the present chapter, we have briefly reviewed knowledge creation approaches to collaborative learning. We used terms such as *trialogue* and *trialogical learning* for those processes where people are organizing activities for developing concrete artifacts and

practices (Paavola et al., 2004). While studying collaborative learning, it is, however, important to see a continuum from "participation" approaches to "knowledge creation" approaches, and from dialogical meaning making to trialogues in terms of collaborative work with shared objects (Paavola & Hakkarainen, 2009). Dialogic theories typically emphasize such things as communication skills, expression of different perspectives, multiple voices, shared meaning, and shared understanding (Stahl, 2006). Artifacts such as reports are mentioned, of course, but primarily as a *means* of dialogue. Trialogical inquiry appears to require extended efforts on the part of the participants, going beyond mere dialogues, for developing shared objects across relatively long periods of time. We emphasize that the objects themselves have a causative role. Trialogues necessarily require dialogue in the process of making and taking perspectives and negotiating their meaning by means of comment and discussion. Yet the defining feature of trialogical inquiry is creative work with externalized ideas and objectification and materialization of ideas to lead to the creation of epistemic artifacts in which subsequent inquiry takes place. Human beings are cognitive overachievers because they use various cognitive extensions for piggy-backing complex cognitions that could not be implemented without external aids (Donald, 2001). By being an intensive part of CL practices, even very young learners may learn to systematically augment their intellectual resources by crystallizing reasoning processes and inquiries to become shareable artifacts; this affects the learners in their joint cognitive processes. The Artifact project involved students learning to systematically capitalize on material-symbolic epistemic artifacts, created by themselves and their fellow learners, in their subsequent epistemic processes.

There is evidence of the educational value of CL in facilitating the development of participating students' agency and a transformation of their identity (Engeström, 1999; Hakkarainen et al., 2004). Productive CL takes place in mediated *interaction between personal and collective activities*. In many cases, individual agents have a key role in knowledge creation processes but are not, in fact, acting individually; their activities rely on a fertile ground provided by collective activities and upon the artifacts jointly created. Becoming a collaborative inquirer is a developmental process in itself. Participation in pursuit of complex collective projects is likely to elicit students' sociocognitive growth. Breaking boundaries between school and cultural communities often provides opportunities for appropriating novel roles and developing one's agency. Novel and more demanding roles become available to students when engaging in extracurricular activities taking place outside of the classroom. It often happens that new groups of students start excelling when engaged in activities across multiple contexts (Roth & Barton, 2004). Epistemic agency in the form of assuming collective cognitive responsibility for collective inquiry efforts appears to be especially important (Scardamalia, 2002). From a sociocultural perspective, learning is not, however, a mere epistemic improvement, but also an ontological transformation (Packer & Goicoechea, 2000) elicited by cultivating CL cultures that allow utilization of errors and mistakes in a safe context as collective learning experiences. Collaborative learning is always multivoiced and heterogeneous in nature. In interactions between teachers and the fresh and unique knowledge and experience of new cohorts of students there emerge practices that neither belong to official school discourse, nor to students' informal discourse; rather they are genuinely collaboratively emergent in nature (Sawyer, 2005), forming a third space (Gutierrez, Rymes, & Larson, 1995). Many aspects of the Artifact project were not anticipated by the investigators and appear to represent just such an emergent phenomenon that is

following its own logic (trialogic!). Participants' activities had deeper meaning and cultural significance that went beyond regular concerns of individual school achievements or a separate school project.

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