Chapter 4
Trialogical Approach for Knowledge Creation

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Introduction

Trialogical learning refers to a novel approach on collaborative learning where the aim is to support participants' sustained activities on developing knowledge artifacts (documents, models, design artifacts, etc.) and cultivating related knowledge practices. The trialogical approach emerged originally from research on technology-mediated collaborative learning and inquiry learning. Information and communication technologies (ICTs) provide tools and instruments that make deliberate building and creation of knowledge accessible even for elementary school students. The terms "trialogues" and "trialogical learning" (or "trialogical inquiry") are quite new in the context of academic discourse related to learning and knowledge creation.[1] The trialogical approach itself is, however, rooted in the theoretical traditions on learning where practices, object-oriented, and artifact-mediated processes are emphasized as a basis for understanding human cognition and epistemic activity more generally. The trialogical approach has an interventionist emphasis.

[1] Dictionaries define trialogues usually as a conversation, colloquy, or discussion between three people or three groups, but the term has been used in different senses (see Wiley 1994). Our use of the term (see Paavola and Hakkarainen 2009) highlights that the interaction between people does *not* happen only through words and concepts and by communicating and changing ideas (like in dialogues) but through developing shared "objects" (artifacts and practices) where the role of shared objects and their iterations have a more prominent role than traditionally recognized.

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S.C. Tan et al. (eds.), *Knowledge Creation in Education*, Education Innovation Series,
DOI 10.1007/978-981-287-047-6_4,

Rather than giving exact pedagogical formulas, it aims at giving guidelines for developing existing pedagogical practices so that collaborative advancement of knowledge artifacts and practices is emphasized.

The Trialogical Approach

The trialogical approach has emerged on the basis of both practical and theoretical considerations on technology-mediated collaborative learning. The aim has been to promote those kinds of processes where students (or participants) are focusing their efforts on developing concrete knowledge-laden artifacts together. This is different from traditional views on learning as knowledge acquisition or participation to social practices. Instead of emphasizing intersubjective dialogue in the way characteristic of meaning-making traditions, the aim of trialogical approach is to promote focused, collaborative work with knowledge artifacts and practices (Paavola and Hakkarainen 2009) and to appropriate associated practices of working productively with knowledge (Hakkarainen 2009a).

Although the trialogical approach has been developed for facilitating advanced processes of learning in education, it is *not* a full-blown pedagogical model with specific stages or guidelines of implementation. It is rather a conceptual framework for examining learning and inquiry processes related to systematic creation and advancement of knowledge. It can be implemented in various ways and gives guidelines for transforming educational practices to facilitate shared efforts of working with knowledge artifacts (Paavola et al. 2011). The aim is to enhance processes on collaborative knowledge creation with concrete outcomes. The trialogical approach has been developed and investigated especially in a large (2006–2011) project called the *Knowledge Practices Laboratory* (KP-Lab) (see especially articles in Moen et al. 2012; cf. also Paavola and Hakkarainen 2005). A specific virtual environment called the *Knowledge Practices Environment* (KPE) was developed for supporting various aspects of collaborative knowledge creation (Bauters et al. 2012; Lakkala et al. 2009).

The focus on the KP-Lab project was on higher education courses where students produced knowledge artifacts (project documents, project works, etc.) in groups. The courses and contexts had quite a lot of variation. For example, there were training courses in medicine where medical students used advanced technologies (with a small manikin having functionalities of a newborn baby) for learning teamwork in cases simulating authentic settings (Karlgren 2012). However, there were also more "mundane" higher education courses (mundane in a sense of not needing any specialized technologies) involved. Students were, for example, producing small design assignments for real customers in a media engineering course, or producing concept maps in pairs on the basis of their own research interests in a course on qualitative methods (see Lakkala et al. 2012), or producing business ideas and technological solutions for customers (Kosonen et al. 2012). These courses were *not* designed originally according to the trialogical approach; rather, they were

chosen for investigation because they already had characteristics of the trialogical learning (see design principles below) and had potential to be developed further (see in more detail Karlgren 2012; Kosonen et al. 2012; Lakkala et al. 2012).

Similarly, the present investigators and their collaborators have promoted knowledge creation practices and trialogical learning by using technology-mediated learning environments to support *collaborative design*. Designing appears be a trialogical process almost by definition because of the importance of a shared object of designing from conceptual ideas to prototypes and actual design artifacts. Together with our collaborators, we have carried out a series of investigations that involve students from elementary (Kangas et al. 2011) to higher education (Lahti et al. 2004) levels designing artifacts in collaboration with domain experts. *Learning through Collaborative Design* (*LCD,* Seitamaa-Hakkarainen et al. 2012) model guides participants to iteratively develop their design ideas and determine design constraints but diverge from the inquiry learning in terms of engaging participants in prototyping and working with materially embodied artifacts. Such experiments have allowed us to extend the inquiry learning approach from conceptual domains to material cultures of artifact creation (Kangas et al. 2007).

Basic characteristics of the trialogical learning have been formulated with six *design principles* (Hakkarainen and Paavola 2009; Paavola et al. 2011; see also Karlgren 2012; Lakkala et al. 2012). They have a dual nature: (1) They point out characteristics that can be called "trialogical" (many existing courses have these features in various degrees); (2) they give broad guidelines for enhancing trialogical features of the learning settings in question.

DP1: Organizing Activities Around Shared Objects

The first DP explicates the central idea of the trialogical approach, emphasizing practices through which participants organize their collaboration for developing "shared objects." These shared objects can be various kinds of knowledge artifacts (documents, plans, designs, models, prototypes, products, etc.) but also shared practices and processes (i.e., ways of working or organizing the collaboration) that may be systematically developed and transformed together. This focus on developing practices and processes appears to be a central characteristic of innovative knowledge communities. "Sharedness" does not mean that participants are necessarily agreeing on objects, but rather that they are focusing on producing concrete things together. One vital feature of the trialogical approach is that the work and versioning of external knowledge artifacts – created for some subsequent purpose and use – are seen to structure human interaction essentially. These shared objects and versioned knowledge artifacts provide a concrete common ground and mediating element for collaboration. At the same time, participants are encouraged and supported in developing and reflecting their processes of organizing their collaboration and ways of working.

DP2: Supporting Integration of Personal and Collective Agency and Work (Through Developing Shared Objects)

In order to understand and support knowledge creation processes properly, the dichotomy between individualistic approaches to learning and purely social interaction is to be transcended (see metaphors of learning below). Efforts and expertise of individual participants often play a crucial role in knowledge creation and advancement processes. As Ritella and Hakkarainen (2012) argued, productive participation in knowledge creation process presupposes transformation of personal operating systems of activity (Donald 2000) in a way that supports technology-mediated knowledge practices. Personal transformation, however, takes place through participation in a community that provides a fertile ground for creative efforts. This means that when people are involved in creative processes, the role of individual expertise is tuned with fertile social and cultural processes (and vice versa). Personally and collaboratively constructed artifacts and practices become resources on which social communities and individuals may build their inquiries. Participants are encouraged to take the agency of their own work, collaborative processes, and those objects that they are developing (see Damsa and Andriessen 2012).

DP3: Fostering Long-Term Processes of Knowledge Advancement with Shared Objects (Artifacts and Practices)

Processes of developing something new together or developing knowledge practices usually require from individuals, groups, and social institutions iterative efforts spanning across relatively long periods of time. The focus of the trialogical approach is on practices and tools that support work with a longer time frame than is often done in educational settings, but it is still focusing on shorter time frame than long-term cultural changes. The focus is on extended processes addressing practices and tools needed for going beyond individual courses. These include various aspects like doing things that are meant for some subsequent use, encouraging links between different courses, creative reuse of previous practices and knowledge artifacts, and providing enough time for iterative cycles needed in knowledge advancement. A focus on sustained processes of knowledge creation is one difference to many dialogical approaches that focus on microanalytic studies of here-and-now discourse interaction. The advancement of knowledge-creating inquiry is not possible without iterative efforts that involve pursuing investigations, getting feedback, redirecting subsequent efforts, and gradually reaching novelty and innovation (Bransford et al. 2006).

DP4: Emphasizing Development and Creativity on Shared Objects Through Transformations and Reflection

A central weakness of various inquiry learning approaches is an exclusive focus on conceptual entities and ignoring materially embodied and practice-related aspects of knowledge creation. The trialogical approach, in contrast, emphasizes development and knowledge creation through interaction between various forms of knowledge and between practices and conceptualizations. Interaction and transformation between such things as explicit knowledge, under-articulated (tacit) knowledge, knowledge practices, and conceptualizations are seen as driving forces in knowledge creation processes. The processes of developing and formulating shared objects together provide mediating elements of knowledge creation. By capitalizing on distributed cognition (Hutchins 1995), the trialogical approach examines knowledge artifacts as materially embodied entities that are worked on in various "external memory fields" (Donald 1991) rather than reduced to their conceptual content (Paavola and Hakkarainen 2009). Elaborating ideas in mind and working on paper are mutually dependent and co-constitutive processes (Ritella and Hakkarainen 2012). In the design of technology-mediated learning environments, it is especially important to provide tools that enable users in externalizing and materializing their intangible hunches and ideas and transform them to digital artifacts than can be subsequently built on, commented on, and raised above by relying on collective cognitive efforts (Bauters et al. 2012; Scardamalia 2002).

DP5: Promoting Cross-Fertilization of Various Knowledge Practices and Artifacts Across Communities and Institutions

In order to provide students with skills and competencies that prepare them to encounter future challenges, it is critical to engage them in solving more varied and complex problems than traditional narrow and impoverished textbook problems (Bransford et al. 2006; Marton and Trigwell 2000). Toward that end, the trialogical approach focuses on learning settings in which students solve complex, "authentic" problems, that is, challenging problems, that have significance and relevance outside the educational setting in question and that are often intended to be used and utilized outside educational institutions (like design assignments or products for real customers, or documents to be used in one's own subsequent research practices). Crossing boundaries between knowledge communities is considered to provide critical experience for knowledge advancement because it makes participants reflectively aware of implicit and partially nonconscious aspects of knowing. This kind of "cross-fertilization" between education, research-related and professional institutions, and practices is an important motivation for students and teaches the competence needed in modern knowledge work.

DP6: Providing Flexible Tools for Developing Artifacts and Practices

As explained above, the trialogical approach capitalizes on the novel affordances of digital technologies to facilitate collaboration around shared objects and organizes activities around advancement of a joint creative endeavor. Information and communication technologies (ICTs) have, as the concept itself suggests, for a long time been seen to support either "the information genre" or "the communication genre" in people's activities (Enyedy and Hoadley 2006); that is, existing ICT is mainly suited for sharing information ("monologues") or for supporting social interaction ("dialogues") as respective social activity. Web-based technology, however, gives new means for collaboratively developing and creating knowledge artifacts and related practices (Hemetsberger and Reinhardt 2006; Lee et al. 2008; Miettinen 2006). The present trialogical approach entails, however, expanding perspective to technology-mediated and knowledge-laden practices of jointly working for creating and extending knowledge artifacts and supporting related object-oriented processes (Bauters et al. 2012; Lakkala et al. 2009).

These design principles above are quite general and leave room for different interpretations. When taken literally, these design principles are also quite demanding. They are meant to give guidelines or be "vehicles of innovations" when ways of promoting trialogical aspects of learning are elaborated. For example, there are different ways of fostering long-term processes of knowledge advancement (DP3) (e.g., by using knowledge artifacts or templates produced by earlier participants as a basis for your own collaboration or trying to implement ways of working found successful by others). It is then up to the participants to decide which parts and how they are to promote these aspects of trialogical learning.

Also in the KP-Lab project, the central focus on "shared objects" ended up having different meanings and interpretations (see Paavola et al. 2012, pp. 10–11):

1. The basic theoretical idea of the trialogical approach has been to support collaborative and iterative work with external artifacts and develop concrete ways of doing things together.
2. In pedagogical cases, a broader and a more abstract interpretation of "shared objects" was emphasized. A central concern was to organize students' activities on shared topics and meaningful assignments where the work with collaboratively developed artifacts (meaning 1 above) can be one central means.
3. Other interesting "object-bound" activities in between trialogues and dialogues were also found which are often used for promoting collaboration. For example, object-bound discussions mean that commenting or discussions are targeted at specific parts of a document instead of more general discussions (see also van der Pol 2007). On the other hand, knowledge artifacts (e.g., visualizations) were developed collaboratively by projecting them onto a screen and then discussed in a face-to-face meeting. So the focus was on developing knowledge artifacts

together (i.e., trialogues), but it required various kinds of supporting object-bound dialogues.

A Background for the Trialogical Approach in the Knowledge Creation Metaphor of Learning

The trialogical approach builds on an emerging trend in theories of learning to understand processes where something new is developed collaboratively (Paavola and Hakkarainen 2005). Preparation to the advanced knowledge society appears to require improved understanding of personal and collaborative processes related to pursuit of innovation and novelties. We have previously referred to these theories and approaches with the term *knowledge creation metaphor* of learning and human cognition (Hakkarainen et al. 2004; Paavola et al. 2002, 2004). Anna Sfard has made a well-known distinction between an *acquisition* and a *participation metaphor* of learning (Sfard 1998). Roughly speaking, the acquisition metaphor of learning refers to traditional theories of learning where information processing within the human mind and the transfer of conceptual and factual knowledge are emphasized. Thus, learning is seen as something where individuals acquire already existing bodies of knowledge. The participation metaphor refers to sociocultural theories of learning that have challenged and questioned the acquisition approaches. Such approaches examine learning as a process of socializing and growing up to social communities and appropriating their shared norms, values, and practices and gradually transforming identity as well. Learning is not seen so much as acquiring something but as a more holistic developmental transformation through doing things in actual contexts.

The knowledge creation metaphor of learning is based on a claim that if theories of collaborative creativity and joint development of novelties are considered, neither acquisition approaches nor participation approaches are sufficient in themselves (see also McLoughlin and Lee 2008; Tynjälä and Häkkinen 2005). We have analyzed (Paavola et al. 2002, 2004) prominent theories on learning and human cognition that represent the knowledge creation metaphor of learning, that is, Bereiter and Scardamalia's (2003) knowledge building, Engeström's (1987) theory on expansive learning, and Nonaka and Takeuchi's (1995) theory of organizational knowledge creation. We maintain that they transcend dichotomies related to the acquisition and the participation metaphors of learning in terms of addressing collaborative processes of pursuing novelty and innovation. People create novelties by organizing their long-term efforts for developing "shared objects," which can be very diverse things like theories, documents, designed and manufactured products, and shared practices being reflected on and transformed.

The trialogical approach has emerged from our efforts of trying to understand commonalities across these approaches that highlighted knowledge creation processes in learning. The aim has been to widen *dialogic* theories and *meaning-*

making traditions prevalent within computer-supported collaborative learning to encompass collaborative work with shared artifacts and practices as well (Paavola and Hakkarainen 2009). The idea is not to make a stark contrast to dialogic approaches but to maintain that there is a need to take the role of collaboratively developed artifacts and objects and associated collaborative practices into account when developing theories of learning.

An important basis for the trialogical learning has been the experiences of developing the inquiry learning model called *progressive inquiry* (Hakkarainen 2003, 2004; Hakkarainen et al. 2004). This pedagogical model is rooted in Bereiter and Scardamalia's (2003) *knowledge building* approach and engages students in systematic efforts of building and creating knowledge related to various aspects of their school learning. Students are engaged in investigative study projects driven by students' questions and intuitive working theories. In the background of progressive-inquiry model is an assumption that learning is similar to inquiry processes where interrogative processes (questions and answers) guide the search for more specific hypotheses and advancement of communal knowledge (Hakkarainen and Sintonen 2002). Research and development efforts of technology-mediated learning environments, such as Future Learning Environment (www-fle3.org), have been engaged to support progressive inquiry (Muukkonen et al. 2005). The investigative practices of learning and instruction based on the progressive-inquiry model have become a very influential model in Finland.

Our investigations indicate that in educational contexts, teachers and tutors play a crucial role in guiding knowledge-creating activity related to progressive inquiry and collaborative designing (Viilo et al. 2011). It was noted early on that it is quite challenging for teachers and students to implement knowledge-creating inquiry cultures (Hakkarainen 2009b, 2010). This is because establishing a successful inquiry culture requires transformation of teachers' and students' social practices; such cultures channel and guide the participants' activities in a way that elicit inquiry. Technology enhances learning only through transformed social practices. The learning of these kinds of technology-mediated practices requires time. The cultivation of *social practices* supporting inquiry learning is as important as the understanding or models on inquiry processes as such (Hakkarainen 2009a). Collaboration should then not be seen just as an *epistemic* issue (around knowledge) but also as a matter of developing collaborative ways of working together.

Even though trialogical processes can be implemented without novel technology, digital technology has provided new means for trialogical processes and collaborative knowledge creation; people can more easily than ever share their work with others and collaboratively and iteratively develop things forward (Shirky 2010). And this is just not happening in traditional educational contexts. The Internet appears to provide novel instruments and methods that allow people to use their free time and efforts (cognitive surplus) to make and share their creations and experience being connected to creative communities. Social media provides novel instruments and methods for functioning as communities, where it did not use to be possible, for developing and advancing shared objects across spatial and temporal boundaries (Rheingold 2002). Open-source development communities

are prime examples of object-oriented distributed knowledge-creating communities (Hemetsberger and Reinhardt 2006; Weber 2004). Wikipedia reveals the creative strength of distributed but coordinated efforts for making and sharing knowledge (Tapscott and Williams 2006). New interest groups emerge in the Internet that involves participants pursuing shared interests (Gee and Hayes 2011). Trialogical activity appears to go beyond mere friendship-driven social exchange ("hanging out") and involves serious development of expertise with extended networks of more experienced peers and expert communities ("geeking out," Ito et al. 2010). Educational investigators are, however, worrying about the existence of a *participation gap* that involves the unequal access to learning opportunities and formative experiences that advanced and creative use of digital technologies requires. In order to provide learners an access to cultivation of creative capabilities that the emerging knowledge society requires, we need to achieve much deeper understanding of the development and dynamics of innovative knowledge communities. The aim of the trialogical approach is to engage teachers and educational institutions with academic researchers and professional communities in collaborative efforts for improving the quality of education by utilizing novel possibilities provided by digital technologies.

Elements of Trialogical Learning

As we see it, the trialogical approach is an outgrowth of many existing long-term developmental paths concerning collaborative learning and human cognition. We will unpack shortly four important theoretical aspects of the trialogical approach: (1) mediation, (2) artifacts, (3) knowledge practices, and (4) object-oriented practices. These are connected to the design principles of the trialogical learning (see above) that bring forth general discussions on knowledge creation.

Mediation

The trialogical approach has its basis on theories of mediation (Paavola et al. 2012). There is a variety of approaches building on mediation as a basis for human activity (see, e.g., Engeström 1987, pp. 37–73). Central influences to the trialogical approach have been activity theory, Popper's (1972) theory of cultural artifacts, and Peirce's (1992–1998) semiotic and pragmatistic theory of mediation. Cultural-historical activity theory builds on Vygotsky's (1978) seminal approach that all human activity is mediated by tools and signs. In activity theory, changes in activities are considered to happen through retooling and remediation where artifacts and tools are used as means of transformation of activities and practices (Engeström 1987; Miettinen and Virkkunen 2005), whereas, the knowledge building approach has its basis on Karl Popper's (1972) theory that maintains that,

besides mental and material realm, there is a realm of cultural artifacts (Bereiter 2002) and these cultural artifacts can be seen as central mediators of human knowledge. According to knowledge building theory, collaboration can be supported with new technology designed for supporting collaborative creation of ideas and construction of local cultural knowledge (Scardamalia et al. 1994). Starting with the Peirce's semiotic pragmatism it can, further, be maintained that human activity is mediated through and through with various kinds of sign processes and embedded in activities and practices. Peirce was also emphasizing the role of external artifacts in "augmenting" human intelligence and cognition (Skagestad 1993) bringing it close to modern ideas on distributed cognition.

The trialogical approach is not so much meant to be a new theory of mediation, but it builds on previous theories on mediation and is targeted for understanding the role of collaboratively developed, concrete artifacts and the new technology for enhancing human collaboration and creativity. New digital technology has provided novel multifunctional tools and artifacts that are changing people's ways of working and collaborating. When designing technology-mediated learning environments, investigators deliberately create new types of external memory fields for supporting trialogical activity. In order to provide adequate support for trialogical learning, such environments need to be designed to provide *multimediation*, that is, integrating and supporting collaborative working with shared objects from different perspectives. In this context, we have found useful Pierre Rabardel's analysis of the four forms of mediation (see Rabardel and Bourmaud 2003; about Rabardel's theory, see Lonchamp 2012; Ritella and Hakkarainen 2012), such as epistemic, pragmatic, social, and reflective mediation. *Epistemic mediation* is related to a process of deliberately creating, organizing, and working with artifacts aimed at knowledge advancement. Crystallization, externalization, and materialization of ideas to knowledge artifacts facilitate advancement of inquiry. Learners may appropriate knowledge-creating practices to the extent that pursuit of epistemic mediation relevant for knowledge creation becomes their second nature, that is, an integral aspect of their operational activity system. *Pragmatic mediation* is involved when providing adequate support and structuring for organizing, planning, and coordinating collaborative knowledge creation processes. *Social* (or *collaborative*) *mediation*, in turn, is related to building and managing networks and social relations around shared objects. Finally, *reflective mediation* emphasizes the importance of making knowledge practices visible and aims at transforming them. In well-designed technology-mediated learning environments, all these aspects of mediation support one another (see Bauters et al. 2012).

Developing Artifacts

As explained above, the trialogical approach emphasizes the role of concrete artifacts as a basis for collaboration (Paavola and Hakkarainen 2009). These mediating artifacts are anchoring and directing collaboration in many ways. Very

diverse approaches have emphasized a fundamental meaning of artifacts for human evolution and cognition. The emergence of external representations and artifacts that allowed overcoming the limitations of human working memory has been crucial in human cognitive evolution (Donald 1991; Sterelny 2004). The artifacts constructed may be interpreted to have "pointers" (hints or implicit directions) regarding what is missing from the picture and providing intuitive guidance for directing subsequent inquiry efforts (Knorr-Cetina 2001). It appears to us that inquirers use deliberately created knowledge artifacts as "stepping-stones" for advancing knowledge and gradually extending boundaries of established knowledge and understanding (Ritella and Hakkarainen 2012).

Cultural-historical activity theory emphasizes artifact-mediated activities that are grounded on practical, everyday activities (Cole 1996) and remediation with novel tools and artifacts when existing activities and routines are not working anymore (Engeström 2001; Knuuttila 2005; Miettinen and Virkkunen 2005). Popper (1972) emphasized the role of cultural or conceptual artifacts for human evolution that is a basis for the knowledge building approach. Wartofsky constructed a program for "historical epistemology" where he pointed out that "[a]rtifact is to cultural evolution what the gene is to biological evolution" (Wartofsky 1979, p. 205). Burkitt (1999, p. 4) combines artifacts to bodily activities: "Artifacts are prosthetic extensions of the body and their use makes possible new ways of knowing the world, along with re-formed bodies with new capacities." These extensions are emphasized also in approaches on extended mind (Clark 2003; Clark and Chalmers 1998). The trialogical approach builds on these approaches highlighting a fundamental sense of artifacts for human cognition. It has, however, a narrower and a more specific focus on those processes where people organize their collaboration for iteratively developing concrete knowledge artifacts and cultivate corresponding knowledge practices.

Developing Knowledge Practices

In the social sciences and organizational learning, there has been for some time discussions on a "practice turn" (Schatzki et al. 2001) that has implications also for learning theories. There is a variety of practice theories (see Miettinen et al. 2012), but in general according to them, practices are seen as materially mediated and/or embodied activities, which transcend traditional dichotomies to human and nonhuman entities (Schatzki et al. 2001). Instead of emphasizing science and research mainly through thinking and representations of ideas, the focus is on context-bound human activities. The trialogical approach aims at supporting similar kind of practice turn in learning even when it is a question of advancing students' work with ideas. Hakkarainen (2009a) has crystallized the perspective with the slogan, "technology enhances learning only through transformed social practices." In order to work as an instrument of learning and teaching, educational technologies have to be integrated, "fused," with the social practices enacted by participants.

This is a reason for introducing the concept of *knowledge practices*. Technology in itself does not change human activities but only through those social practices or "knowledge practices" which it entails. Knowledge practices refer here on socially-historically created behavioral patterns, routines, or ways of working with knowledge and knowledge artifacts. These practices comprise multilevel, complex arrays of activities.

It is then essential to expand the perspective from mere technological tools to social practices of their usage (Hakkarainen 2009a; Hakkarainen et al. 2009). It appears to us that otherwise attractive visions regarding the emergence of collectively intelligent Metaweb (Nova Spivack[2]) are "flat" because these are assumed to arise from increased information connectivity, on one hand, and social connectivity, on the other hand. Visions of *the pragmatic web* (see Hakkarainen et al. 2009 for references) guide one to examine social practices related to the historical-developmental use of technology, as the topography or a third dimension of the Metaweb, a dimension that reveals an extremely rough terrain of the surface.

In order to transform technological artifacts as instruments of their activity, participants have to go through a developmental process of "instrument genesis" (Rabardel and Bourmaud 2003; see also Ritella and Hakkarainen 2012) that only intensive use of technology in practice brings about. Ideas and visions of the pragmatic web underscore the crucial role of social practices for gradual learning and socialization for using ICT. Going through instrumental genesis in learning to use a new technology and appropriating associated knowledge practices initially requires an investment of both personal and collective efforts like climbing to the top of a steep mountain. Required cognitive adaptations do not take place without an effort of adapting, tailoring, and reformatting technology-mediated competences. After going through such an effort, the participants may be reluctant to start climbing another mountain without good, motivating reasons. Personal appropriation of even relatively simple technology, such as email, is initially challenging because it requires appropriating new social practices in gradually adapting and changing one's cognitive-cultural operating system of activity.

Remediating practices of classrooms or whole educational institutions by ICTs appears more challenging than transformation of personal knowledge practices. Going through transformation is challenging because there are no ways of moving directly from present to new practices; an iterative process of remediating and transforming practices gradually, step-by-step, is needed. The participants cannot plan exact route across an unknown territory beforehand but have to learn to negotiate partially unexpected challenges and obstacles. Consequently, novel technology-mediated practices of learning and instruction are likely to consolidate very slowly, and progressions tend to take place in courses and practices of enthusiastic and committed teachers with a high level of technological fluency (Barron 2006).

[2] See http://novaspivack.typepad.com/nova_spivacks_weblog/2004/04%20/new_version_of_.html

It seems that successful cultures of trialogical learning are simultaneously also expansive-learning communities (Engeström 1987) focused on problematizing current practices, envisioning changes, and gradually, step-by-step, consolidating novel knowledge practices (Hakkarainen 2004; Hakkarainen et al. 2008). New practices do not emerge from scratch but require deliberate and iterative efforts of transformation under the guidance of teachers and students. Hakkarainen (2013) argued that learning across cohorts or generations of inquirers is one of basic mechanisms of human collective creativity. Such expansive community-appropriate new ICT tools go through personal and collective developmental processes and cultivate "information ecologies" (Nardi and O'Day 2000) for creating innovative local practices of using technology.

Object-Oriented Activities

Objects and object-orientedness of human activity are basic concepts in activity theory (see Engeström and Blackler 2005; Kaptelinin and Miettinen 2005; Miettinen 1998). In activity theory, objects have thinglike characteristics, but they are also something to which actions are directed. This idea of object-orientedness of human activity is used also in many other approaches nowadays although, not in a similar, basic theoretical meaning than in activity theory. According to Knorr-Cetina (2001), knowledge-centered practices of modern professionals are not to be understood as iterative and habitual routines, but more dynamically oriented toward epistemic objects. For Knorr-Cetina, these epistemic objects are material in some sense, but more importantly for her, they are open ended and always in the process of being developed and also materially defined (pp. 181–182). Another influential approach in social scientific and organizational studies on object is the notion of *boundary objects* (Star and Griesemer 1989). Boundary objects are objects that are used in boundaries of different actors or organizations or within intersecting social worlds. Objects have a broad meaning here; as examples of boundary objects, Star and Griesemer have analyzed, for example, repositories, ideal types, and standardized forms. Boundary objects are "both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites" (p. 393).

The trialogical approach highlights the object-oriented nature of human activities and work with shared objects (cf. also Lund and Hauge 2011; Muukkonen-van der Meer 2011). Analogously to what was said on mediation above, the trialogical approach aims not to be a new theory on object-orientedness but highlights those processes where collaboration is organized for developing collaborative knowledge artifacts and practices. Collaboratively developed knowledge artifacts are "intermediate objects" constructed for advancing knowledge in a specific situation. Artifacts created for such specific purposes guide and provide stepping-stones for subsequent knowledge-creating efforts. Hence, knowledge artifacts constructed are

oriented toward the "final" object of the work, including various unforeseen uses and effects. Accordingly, these shared objects have similarities to boundary objects by being concrete things that are structuring the collaboration. Shared objects and artifacts are making such cooperation possible, which does not require consensus to begin with (in contrast to many other approaches) (see Star and Griesemer 1989, p. 604). As a difference to boundary objects, these shared objects do not need to be necessarily in between boundaries, and they are dynamic from the start. They are meant to be developed and modified collaboratively, while boundary objects are often conceived as quite static in themselves (see Ewenstein and Whyte 2009).

Trialogical Approach in Relation to Other Theories on Knowledge Creation

The trialogical approach has taken influences on different approaches, representing the knowledge creation metaphor of learning like the theory of *organizational knowledge creation* (Nonaka and Takeuchi 1995), *knowledge building* (Bereiter and Scardamalia 2003), and *expansive learning* (Engeström 1987). It has been maintained that even when showing general commonalities between educational and cognitive theories, there is a risk that the knowledge creation metaphor ends up being eclectic (Engeström and Sannino 2010, p. 18). There are clear epistemological and ontological differences among these theories on knowledge creation that these differences should not be ignored. We agree with this. In *organizational knowledge creation*, the focus is on how organizations process knowledge from the point of view of business, and the theory emphasizes the interplay with tacit and explicit knowledge and knowledge conversions at different levels (individual, group, organization, interorganizational level) (Nonaka 1994). *Expansive learning* is a theory on communities of learners and transformations on activity systems where learners construct and implement wider and more complex objects for their activities (like professionals redefining their ways of working when new challenges and risks threaten their work). *Knowledge building* is basically an educational approach, arising from computer-supported collaborative learning, and entails knowledge builders working with improvable ideas with the educational technology supporting their work.

The underlying *epistemology* is also quite different in the three theories representing the knowledge creation metaphor. The starting point for the organizational knowledge creation is tacit knowledge developed in relation to organizational learning and Japanese intellectual tradition emphasizing "onenesses" (humanity and nature, body and mind, self and other), which is in contrast to Cartesian rationalism and dichotomies (see Nonaka and Takeuchi 1995, pp. 27–32). Expansive learning has a rich background in the Russian cultural-historical school where contradictions, object- and future-oriented activities, as well as mediation by cultural tools and signs play a crucial role (see more in Engeström and Sannino

2010, pp. 4–5). Knowledge building leans on theories related to the use of technology to scaffold expertise in writing. It builds especially on Karl Popper's theory on "World 3" of public knowledge and conceptual artifacts in distinction to the material and mental realms ("World 1" and "World 2"). Knowledge building focuses more on intellectual problems, whereas expansive learning focuses on practices and contradictions on activities (and activity systems). In organizational knowledge creation, the focus is on product and process innovations in business (Nonaka and von Krogh 2009, p. 646).

While acknowledging differences among these theories, we think that it is worthwhile looking at their commonalities. It would be totally unrealistic to think that there could be a metatheory on knowledge creation. Different approaches of knowledge creation are built on different traditions of research and focus on different aspects on knowledge creation, and because of that, they are putting forth different alternatives. Still, these theories on knowledge creation are not static themselves, and their development does not happen in a vacuum. The function of the knowledge creation metaphor is to point out emerging trends in theories on learning and human cognition that are important when approaches on knowledge creation are developed further.

One commonality in theories representing the knowledge creation metaphor is the societal need for a new approach on learning. The focus is not the same but the need for something new is quite similarly emphasized. It can be, of course, maintained that this is only rhetorics. Here we think, however that the rhetorics show a deep change in modern societies. According to Nonaka, the so-called knowledge society "calls for a shift in our thinking concerning innovation in large business organizations. . . It raises questions about how organizations process knowledge and, more importantly, how they create new knowledge" (Nonaka 1994, p. 14). According to Scardamalia and Bereiter (2010), knowledge building focuses on "the 21st century need to work creatively with knowledge." The basis for expansive learning is a broader societal need: "The ultimate test of any learning theory is how it helps us to generate learning that penetrates and grasps pressing issues the humankind is facing today and tomorrow" (Engeström and Sannino 2010, p. 21). Shortly, traditional epistemologies and learning theories are not enough especially if their focus is on processing existing information or solving existing problems. It is crucial to achieve a deeper understanding on collaborative processes and practices and create novelty and innovation (how new things emerge and are developed collaboratively). Toward that end, it is essential to examine human learning from a more developmental perspective that will address creation of novelty in conjunction with growth of the participants and transformation of their practices.

These theories transcend many traditional dichotomies concerning learning and human cognition (Paavola et al. 2004, pp. 562–566). That is, if the focus is on collaborative creativity, both individuals and social processes must be taken into account, and both conceptual knowledge and social practices must be emphasized. The knowledge creation approaches emphasize *mediating elements* between subjective and objective worlds to avoid Cartesian dualisms, and they aim at describing

how activities are organized around *shared objects*. The focus is on "real" problems, that is, problems and issues that have meaning outside a specific educational setting. Generally speaking, the focus is on problem solving but not just on solving existing problems but being able to create and define focal problems by the participants. All these theories highlight diversity, variety, and multivoicedness as a requisite for innovation (e.g., Engeström and Sannino 2010; Nonaka 1994; Scardamalia and Bereiter 2010). This requires that traditional hierarchical structures be changed so that all complementary and relevant voices are involved. Knowledge creation processes are not linear but entail surprises and messiness, which are directed at expansive and improvable processes and toward novel syntheses. One focus is the new kinds of an agency needed. Scardamalia and Bereiter have highlighted that knowledge building is *not* something that comes naturally but requires specific efforts and epistemic agency of participants. Overcoming the creative participation gap (Jenkins et al. 2009) mentioned above requires intentional facilitation, guidance of collaborative building, and creation of knowledge from educational institutions. Expansive learning is usually connected to deliberate efforts and interventions to solve pressing contradictions of existing practices. Nonaka (1994, pp. 17–18) has highlighted intentionality and autonomy as a basis for converting meaningless information into targeted knowledge creation.

The trialogical approach has been influenced by theories representing the knowledge creation metaphor of learning, but it has a theoretical and practical focus of its own. Like knowledge building, it has its background on technology-enhanced collaborative learning in educational settings. It aims at helping students to create knowledge artifacts together. But unlike knowledge building, it also highlights material and pragmatic aspects of collaborative knowledge creation. The focus is not just on ideas and idea improvement, but also on practical criteria and material aspects directing collaboration. That is why in the trialogical approach, the focus is not just on epistemic mediation but also on pragmatic, social, and reflective mediation. This is why we think that Popper's "World 3" emphasized in knowledge building ends up being too distinct from practices and material issues and Peircean and Vygotskyan approach to human-mediated activity provides a better theoretical grounding for theories on knowledge creation (Paavola and Hakkarainen 2009).

The trialogical approach has taken many influences from expansive learning and cultural-historical activity theory. The focus is on artifact-mediated activities and on practices and object-orientedness of human activity. But in distinction to expansive learning, the trialogical approach is not a theory on transformations of human activity systems. The trialogical approach focuses more narrowly on questions concerning how to organize students' or participants' work on developing shared knowledge artifacts together and how technology supports this collaboration.

The trialogical approach has much less direct influences from the theory of organizational knowledge creation, but the use of different forms of knowledge and their conversions is seen as important. The trialogical approach has originally been developed within the context of technology-enhanced collaborative learning.

Affordances provided by technology-mediated learning environments for creating, discussing, elaborating, and building on shared knowledge artifacts have affected the emergence of the trialogical framework (Hakkarainen 2009a; Paavola and Hakkarainen 2009). The role of knowledge artifacts and their iterations are emphasized which bring in mediating elements that are not prominent in the theory by Nonaka and Takeuchi. The trialogical approach is an educationally oriented approach; it aims at giving guidelines and design principles for collaborative learning.

Conclusions

In this chapter, we have delineated the elements of the trialogical approach to learning and how it relates to broader perspectives on knowledge creation. The trialogical approach is a result of quite a long evolution. It has started with comparisons on different theories on processes of knowledge creation. The trialogical approach is not a well-specified pedagogical model, but it has guided further cultivation of pedagogical approaches such as the *progressive-inquiry* model and *learning through collaborative design* framework or technological environments like Knowledge Practices Environments (KPE). It is more like a framework that assists investigators and practitioners to examine and develop those technology-mediated processes and practices that involve collaborative efforts of building and creating knowledge artifacts and practices together. It is a weakness in that there are no clear guidelines for students and teachers for implementing it. It is a strength as it gives hints and ideas for changing existing practices to have more object-oriented activities and trialogues. The idea of trialogical approach has given impetus for advancing both research and development of technology-mediated collaborative learning (see Paavola et al. 2011).

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