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From meaning making to joint construction of knowledge practices and artefacts – A trialogical approach to CSCL

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Abstract: CSCL research is often closely connected to dialogic theories of learning and human cognition with an emphasis on shared meaning making. Without neglecting this viewpoint we give reasons for an alternative framework. We call this alternative a "trialogical" approach; it emphasizes joint and organized work with artefacts and practices as a basis for collaborative learning. The paper explains the use of this notion and clarifies theoretical backgrounds for the approach in line with the knowledge creation metaphor of learning, and relates it especially to knowledge building and socio-cultural and cultural-historical theories of human cognition. Various theories concerning mediation are briefly analyzed. The paper also explains how dialogues and trialogues are close to each other if, for example, the role of common ground is analyzed further. Lastly, design principles of the trialogical approach are concisely described.

1 Introduction

It appears that throughout its relatively short history Computer-Supported Collaborative Learning (CSCL) has aimed at defining its paradigmatic starting points (see Koschmann 1996, 1999, Koschmann et al 2002; Stahl et al 2006). This is not surprising because CSCL has been an emerging research field which is clearly connected to novel

ways of understanding fundamental epistemological, methodological, and also ontological questions concerning human cognition and activity. CSCL is married to basic conceptions of the socially, materially, culturally, and technologically distributed nature of human cognition. Yet there are different interpretations how these challenges and possibilities are interpreted, and which broader research traditions provide as a background for CSCL research (e.g., neo-Piagetian framework, a socio-cultural approach, situated cognition, knowledge building).

One very prominent candidate for providing the foundations for CSCL is closely connected to dialogic theories of learning and human cognition, and interactional or shared meaning making (Koschmann 1999; Stahl et al 2006; Wegerif 2006; Suthers 2006). This is a quite appealing approach for understanding the basics of CSCL. It seems, at least in general terms, to fit nicely to many approaches important in the CSCL tradition, such as Bakhtin's ideas of multiple voices (Koschmann 1999), inquiry processes with question and answers (e.g., Muukkonen et al 2004), argumentative skills (e.g.. Andriessen et al 2003), or more general skills of communication and dialogues (Wegerif 2006). In more general terms, this can be connected to the idea that human cognition is mediated by tools (especially by technology) and by signs (Vygotsky 1978). Sign-processes are usually interpreted as fundamentally dialogical (see Wertsch 1991; also Peirce 1931-1958).

There are clear differences how the dialogic approach is interpreted within the CSCL tradition. For example, Wegerif (2006; 2007) makes a clear separation of the dialogic approach from the dialectic (and Vygotskyan) tradition whereas Koschmann has interpreted them more in line with each other (Koschmann 1999). Still, dialogic theories have been seen to provide a basis for CSCL because they lay a foundation for understanding meaning making involved in collaborative discussions mediated by computers.

Despite strong arguments to support the claim that the dialogic theories and meaning making form a basis for CSCL, the present paper is focused on developing a different way of considering the foundations of CSCL; we develop on object-centered, trialogical approach to CSCL that appear to bring issues different from the dialogical approach to the foci. The argument is not that the importance of meaning making and dialogues should be neglected, but rather that is should be supplemented with

approaches emphasizing joint work with artefacts and practices. In this paper we aim at giving theoretical reasons and background for this kind of a shift towards, what we call, a "*trialogical*" emphasis of CSCL, and shortly explain our own work with this emphasis. We do not, however, see dialogical and trialogical approaches are mutually exclusive but examine a continuum from dialogues to trialogues.

2 From the knowledge-creation metaphor to trialogues

We have previously maintained that it is useful to differentiate a *knowledge-creation metaphor* of learning as a third main metaphor for learning as a supplement to Anna Sfard's distinction between the *acquisition* and the *participation* metaphors of learning (Paavola et al 2002; Paavola et al 2004; Hakkarainen et al 2004; Sfard 1998). The idea has been that there are different theories of collaborative work and learning which, despite their clear differences, have also a common aim of explicating collaborative processes of creating or developing something new. As representative theories of the knowledge-creation metaphor we have ourselves analyzed especially Bereiter's knowledge building (Bereiter 2002), Engeström's expansive learning (Engeström 1987), and Nonaka & Takeuchi's organizational knowledge creation (Nonaka & Takeuchi 1995). These theories have clear affinities to theories representing the participation metaphor of learning but still have a different focus especially when directed to processes clarifying collaborative or distributed creativity. The knowledge-creation metaphor is not meant to be a theory of collaborative learning but more like an umbrella term (or a meta-theoretical conception) highlighting underlying similarities across otherwise quite different theories and approaches to collaborative learning and work. We think that it is useful to point out similarities and fruitful tensions between these theories.

On the basis of these theories representing the knowledge-creation metaphor we have tried to analyze what can be learned for developing central aspects of collaborative learning further. From this analysis we have proposed the term 'trialogical' (or 'trialogic') to refer to those processes where people are collaboratively and systematically developing shared, concrete "objects" together (Paavola & Hakkarainen 2005). The basic idea of trialogues is that "objects" (conceptual or material artefacts, practices, ideas) are brought to a more central role than in many traditional theories of

human learning. It can be maintained that if the focus is on how people jointly develop and create such 'objects', many dichotomies connected to the learning theories must be thought anew; for example, both individuals and social processes must be taken into account, and both conceptual artefacts and practices are important. We think that theories representing the knowledge-creation metaphor are just aiming at finding ways of overcoming these kinds of dichotomies to understand the dynamics of collaborative creativity.

In trialogues, the interaction through "shared objects" that are in the process of being developed is emphasized (see Figure 1). These objects of inquiry can be knowledge artefacts, practices, ideas, models, representations, etc. but understood as something concrete to be developed collaboratively. These objects or drafts of objects have a prominent role in the interaction (so it is an interaction between subject(s), other subjects, and "objects", not, for example between subjects). The temporal dimension is also important in trialogues in terms of the shared objects being developed and modified iteratively; novelty and innovation emerge only through sustained processes. The objects being developed are meant for some subsequent use and/or potentially to be modified later on. This anticipation of use provides criteria to modify the object collaboratively. In trialogues the object is something concrete (even ideas and conceptions must be externalized to be shared and developed) but at the same time it is something in the process of being developed (cf. epistemic artefacts – Knorr-Cetina 2001). Trialogues mean, then, those processes where things are developed collaboratively; there is not just work with static objects. The emphasis is on developing something new collaboratively, not repeating existing knowledge.
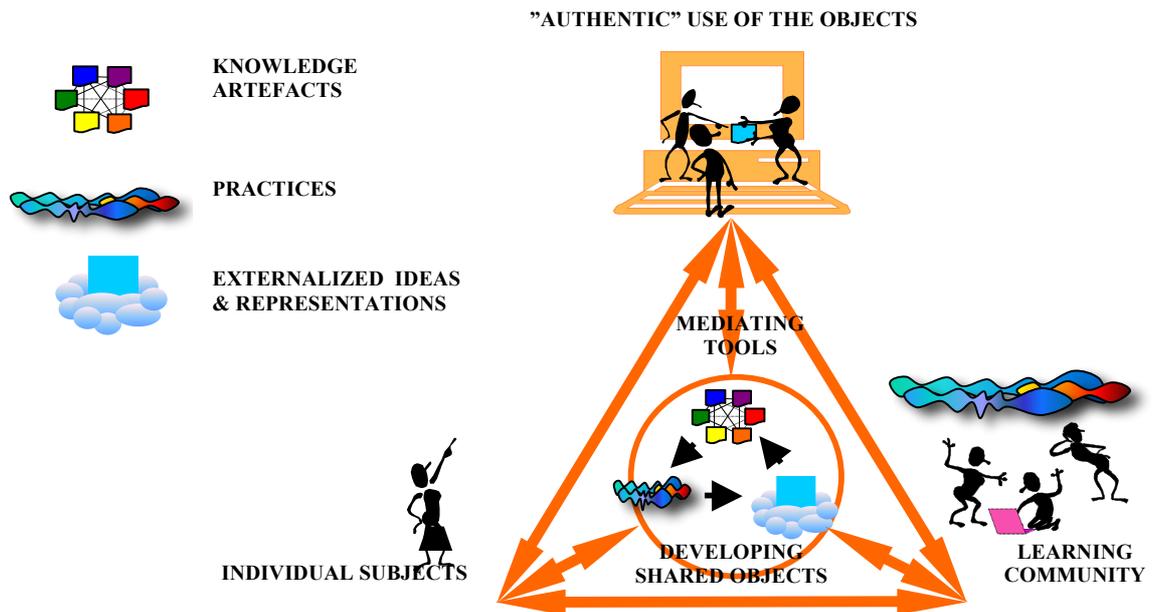
Figure 1. An illustration of the trialogical approach to learning presenting some of the basic elements of it.

One important background for the trialogical approach is the *knowledge building* approach. Knowledge building derives from Karl Popper's (1972) idea of three "worlds" as a basis for understanding human epistemology. According to this, human beings are special in being able to produce cultural or conceptual artefacts which are something different from mental processes within human brain or head, or material things. Carl Bereiter and Marlene Scardamalia (Scardamalia & Bereiter 1994; Bereiter 2002) with their colleagues have developed this approach very systematically to emphasize a joint idea improvement by students supported by specialized technology for knowledge building.

Knowledge building can also be interpreted as a form of a trialogical process although our own interpretation of trialogues emphasizes more the role of practices and material aspects of artefacts than is the case in knowledge building (Hakkarainen, in press). The strength of knowledge building is that it emphasizes so emphatically ways of organizing students' work for collaborative idea improvement. But the cost is that it easily loses sight of more "mundane" practices and processes, and also of the ways that conceptual artefacts must be material and concrete to be shared and developed

collaboratively. Knowledge building has leaned heavily on Popper's epistemology with three "worlds" (material, mental, and cultural/conceptual), but we think that broader, and also more elaborate epistemology would be provided by Charles S. Peirce's sign-theoretical approach. In this kind of a Peircean approach three "categories" (ideas/qualities – actual things – mediation/conceptions) are intertwined, and the meaning of conceptions is closely related to practicalities and "brute" happenings of the world (Peirce 1931-1958). Without going in any detailed arguments, we think that Peirce's and Popper's epistemology are closely related (see Skagestad 1993) but Popper's epistemology easily creates a conceptual "world" which is too separate from other aspects of reality.

Another central background for the notion of 'trialogues' is the socio-cultural theory, and the *cultural-historical activity theory*. The cultural-historical approach builds on the idea that human activities are mediated by artefacts, used and modified by succeeding generations of human beings and grounded on practical, everyday activities (Cole 1996, 108-110). Praxis, or practices, and cultural artefacts are developed in interaction with each other in historically situated and evolving processes (Miettinen & Virkkunen 2005). Human activity is "object-oriented" which means that also collective activity has an object of activity (related to the "motive", or to the concrete outcomes of that activity) which characterizes how activities are, in general, understood or explained (Engeström 1987).

This is in line with Marx Wartofsky's (1979) historical epistemology according to which structures that constrain and guide human perception and action are not universal and unchangeable – as assumed by Immanuel Kant – but products of human history, being continuously created and transformed by human beings. According to Wartofsky modes of cognitive praxis are subject to historical development. The central idea is that epistemic artefacts profoundly change the nature of humans' epistemic activity in general, and learning in particular, so that "artifact is to cultural evolution what the gene is to biological evolution" (Wartofsky 1979, p. 205). Wartofsky separated different levels of artefacts; *primary artefacts* are tools and practices directly used in human labour and other activities, *secondary artefacts* are "symbolic externalizations" or "objectifications" of primary artefacts; and *tertiary artefacts* that mediate relations between primary and secondary artefacts and no longer have a direct representational

function but represent visions, anticipated changes and possibilities that may be used to change the world. Wartofsky also maintained that these artefacts are not in the mind as mental entities, but are externally embodied in socially shared practices, social organizations, and culturally shared ideas.

The notion of "trialogues" owes, then, a great deal to socio-cultural and cultural-historical theories about human cognition. We think, however, that trialogical processes of knowledge creation can be and have been developed within many research traditions (without necessarily using the term "trialogues"), so the meaning of these processes should be seen across various research traditions. Trialogues concern those processes where people organize their work and creativity for developing some concrete (material and conceptual) artefacts and/or practices together for some subsequent use by developing various versions of the artefacts and/or practices often in long-term processes. According to Knorr-Cetina (2001) the work with *epistemic objects* and *epistemic practices* more and more characterizes modern knowledge work. Epistemic objects or 'epistemic things' (Rheinberger 1997) are knowledge objects which are in the process of being defined, and more open-ended than traditional 'objects' (typical examples are objects investigated by scientists which are often in the process of being defined as the end result of the investigations, but there is no "end" point for these future oriented processes). Similarly practices have been traditionally defined as recurrent processes and rule-based routines but modern epistemic practices challenge this viewpoint (see also Miettinen & Virkkunen 2005). Knowledge-centered work requires a more dynamic, creative, and reflective notion of practice. We maintain that these processes with epistemic objects and epistemic practices are trialogical processes.

The term of '*object*' or '*shared object*' is used in this paper in a theoretical sense. Objects or object-orientedness of human activity has aroused a lot of discussion lately, especially within activity theory (Kaptelinin & Miettinen, 2005; Engeström & Blackler, 2005; Miettinen, 1998). For us, object-orientedness gives an important perspective on learning and the design of educational settings also outside the framework of activity theory. We are applying ideas of object-orientedness from activity theory more generally in order to build a framework where collaborative work with shared objects is emphasized as a potential design principle of educational practice. Shared objects can then be knowledge artefacts (papers, models, plans), or

practices which are developed iteratively together. In the "trialogical" sense the notion of an 'object' comes close to epistemic objects defined by Knorr-Cetina (2001), and is related to at least two basic meanings of the term also in a colloquial speech. Objects have concrete, thing-like characteristics but they are also something to which actions are directed (cf. Engeström & Blackler, 2005). "Trialogical objects" are those thing-like practices or artefacts which people are jointly modifying or versioning, but in order to understand the process of developing these "trialogical objects" it must be understood to which purposes and by which means they are produced. By paraphrasing Peircean semiotics: there must be also at least "final objects", which are giving guidance to the process (not "final" in an absolute sense; also these final objects are changing; but towards which the activity is directed). As an example: if people are jointly modifying and versioning a research paper (which is then a trialogical object) they have some ideas of what it should look like (about its structure and content, etc., that is, about its "final object").

We are *not* maintaining that theories and approaches mentioned above are an exhaustive list of theories analyzing trialogical processes. For example, Papert's constructionism (Papert & Harel 1991) comes close to many aspects emphasized in trialogues[1]. Constructionism emphasizes people as active constructors of their knowledge (similarly to constructivism) but not so much construction of mental models (or related things) but things of the real world, usually co-designing something tangible (like building LEGO/Logo). Instead of "instructionism" (and transmission of knowledge) it focuses on constructionism, and more long-term work with meaningful products. Resnick (1996) has introduced the term distributed constructionism to highlight constructionism with things that are seen important in distributed cognition, like collaboration and the use of technology to support constructions. We see these as ways of enlightening different kinds of trialogical processes. Above are mentioned mostly those theories which have influenced our own conception of trialogical processes.

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[1] We thank the anonymous reviewer of this paper for pointing out this connection.

If trialogical processes are treated in many approaches, why to name them with a new term?[2] Is there anything novel here? We think that it is important to emphasize the meaning of these kinds of processes, and to develop ways of analyzing and supporting them. These processes are easily neglected and especially an interaction between various processes supporting trialogues are not seen (for example, work with knowledge artefacts and practices) when CSCL approaches are developed. In this sense it is useful to see similarities and differences within various theories concerning mediation or mediated activity, like Popper's theory of three worlds, Peirce's sign theoretically and pragmatically oriented theory, and Vygotskyan tradition (socio-cultural and cultural-historical theories) with the aim of developing them further (cf. Engeström 1987, 37-73). We have tried to give above some hints of potential re-evaluations from the perspective of "trialogues". Popper's (and Bereiter's) cultural or conceptual artefacts could be interpreted more closely related to practices and material things. Peirce's sign processes can be interpreted more like joint work with external artefacts in culturally embedded processes. Vygotsky (1978, 40) maintained that human beings can control their behaviour as if outside (i.e. culturally) by the means of signs and tools which mediate human activity. In trialogical processes these mediating elements are artefacts and practices which can be taken to be jointly constructed and developed (see Miettinen & Virkkunen 2005; 2006).

One paradigmatic example of a trialogical work process is the way joint research articles (as shared "objects") are produced in successful, collaborative processes. Often one person has the most central role of organizing the work and producing the basic parts of the text, but in successful cases, other writers can add and modify important parts of the text, so that in the end it is not easy to remember exactly who has produced which part of the text. The article itself, or more specifically, drafts of this article have an important role of organizing the work and suggesting and

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[2] The term "trialogues" have been used before in a bit different senses. Dictionaries define trialogues sometimes as a conversation, colloquy or discussion between three people or groups (or see a bit different meaning: Wiley 1994). Etymologically the term might be a bit clumsy in our usage (thanks for Alexander Porshnev for pointing this out) but we are using it to refer to mediated processes (with triadic structures) and as an alternative to dia-logues with the start of 'tria-'. In dialogues interaction happens through words and concepts and by communicating and changing ideas, in trialogues it happens through developing shared "objects" (artefacts, or practices)

constraining how to continue to modify and develop it. Sometimes two (or more) persons have so much common ground and overlap in their research interests that they can create a joint research paper on the basis of their previous texts without knowing in detail who has been responsible for producing which part of the text but the text itself instigates new ideas. There are many things that influence to the good result; agreement and trust on each others working practices is central part of these kinds of processes, as well as feedback from persons outside.

Another example is from the working life context when activities or routines are taken as a joint object of inquiry to be developed (Engeström 2001; Miettinen & Virkkunen 2005). This requires the use of various kinds of models and concepts but the object of inquiry in these cases is the practices and activities, not conceptual artefacts as such.

3 From dialogues to trialogues

We think that it is important to see a continuum (theoretically and practically) from dialogues (and meaning making) to trialogues (collaborative work with shared objects). Dialogic theories typically emphasize such things as communication skills, expressions of different perspectives, having multiple voices, sharing meaning, providing shared understanding. Trialogical processes seem to require extra efforts from people (even more than dialogues). Trialogues require usually dialogues, that is, negotiations on meanings, commenting, discussions, etc. Sometimes it is hard to make a distinction between the two. Still, the differences between these two should be seen and analyzed.

One fundamental problem and challenge (also a theoretical problem) emphasized in dialogues is how human beings are able to focus on certain issues with their multiple voices, perspectives and languages, or how they can reach mutual understanding (see Arrighi & Ferrario 2008) . One answer (or an outline for the answer) is provided with the notion of *common ground*. In order to ensure communication people must have ways of grounding and providing common ground for their dialogues, that is, to have some degree of shared history or knowledge in common to ensure that they are not talking about totally different things or using language with totally different meanings (Clark & Brennan 1991).

Peirce already emphasized in his theory of signs that signs and dialogues are not understandable without such common ground or "collateral observation".

> "The universe must be well known and mutually known to be known and agreed to exist, in some sense, between speaker and hearer, between the mind as appealing to its own further consideration and the mind as so appealed to, or there can be no communication, or 'common ground,' at all." (Peirce 1931-1958, 3.621; see also ibid., 6.338; 8.179)

Peirce emphasized the use of indexical signs which refer to some existing or actual happenings or objects (in real or fictional world) common to those who are in dialogues with each other to convey any meaning (Peirce, 1931-1958, 8.112).

Arrighi and Ferrario (2008) have emphasized that human beings very often correct and reshape the common ground during conversation. This happens by taking extralinguistic aspects into account while interpreting each other's sentences or utterances. People are interpreting utterances, and constructing their common ground intersubjectively (by negotiating on meanings), and by being in interaction with their environment (ibid.). Common ground is not something static but in the process of being negotiated in relation to (indexical) features of the environment.

Arrighi and Ferrario relate this approach to Donald Davidson's ideas about triangulation as a basis for human cognition and knowledge. Davidson (2001) maintains that epistemology should be built on a model where subjectivity, intersubjectivity and objectivity are inseparably linked (in contrast, for example, to the Cartesian epistemology which starts from a quest for subjective certainty). Knowledge of other minds, knowledge of our own minds, and knowledge of the world are mutually dependent, and cannot be reduced to each other. It means, for example, that if we are aiming at understanding the meaning of words, or how signs are used, we cannot start from "objective" meanings of words and signs, nor from subjective meanings, or not even intersubjective or cultural meanings but fundamentally from a dynamic theory where subjective meanings, intersubjective aspects, and objective facts and happenings are all taken into account.

A bit similar broadening of the notion of common ground is provided by the approach of "anchored discussion" (Van der Pol 2007). Online discussion can be supported by anchoring it to study material or documents which are the topic of the discussion. So instead of having more commonly used threaded discussion, grounding is made easier by having tools where study materials and documents to which discussion is referring is available on the screen, and annotations and notes can be pointed to specific parts of the documents (ibid.).

These approaches to dialogues where the role of constructing common ground with Davidson's frame of triangulation, and anchored discussion with indexical relations between discussions and study material being discussed come very close to the ideas of trialogues, as also noted by these authors (Arrighi & Ferrario 2008, 82; Van der Pol 2007, 127). The difference is that in trialogues the central aim is not to enhance dialogues but the common ground is provided by jointly constructing external representations, practices and artefacts (dialogues can, of course, help here). In trialogical processes the common ground is deepened (and provided) by modifying those artefacts and practices ("shared objects") which are objects of joint activity. In trialogues we are not interacting only with words or concepts (emphasized in dialogues) but also modifying conceptual artefacts, external representations, and practices. We are (or can be) both indexically and symbolically attached to the shared objects. Participants of joint activity do not need necessarily to have complete agreement or shared understanding of these shared objects (which is the same with the common ground in general), but these shared objects provide a concrete reference point which can then be collaboratively modified and clarified during the process.

Another way of "broadening" dialogues towards trialogues, or seeing this connection, is to use inquiry models or question-answer processes as a starting point. The interrogative model of inquiry conceptualizes epistemological processes as question-answer steps (Hintikka 1999; Hakkarainen & Sintonen 2002). Human beings (as inquirers) acquire knowledge by putting questions to other humans or to the "nature". According to this formulation, also nature can provide answers to questions provided by the inquirer, for example, with experiments. These formulations capture an important basis of epistemology for inquiry processes. We think, however, that this kind of a framework should be broadened if conceptions about distributed cognition are

taken into account; and this is a way of coming close to the trialogical processes (Paavola et al 2006). The distributed approach means that the role of external artefacts and practices frame the way how people are putting questions and giving answers during the process of inquiry. Existing artefacts (theories, models, methodologies, etc.) and practices give elements and basic means for the question-answer steps, and usually the aim is also to modify and frame novel artefacts and practices during the process.

Instead of having a "game" with two players (either the inquirer(s) and nature, or the inquirer and a community) the basis for trialogues is then a model with three players: an inquirer (making questions, giving answers, or interpreting), "nature" (i.e. the target of the research including artefacts and practices), and a community (making questions, giving answers, or interpreting) (cf. Pera 1994). Inquirers are making inquiries about nature with other inquirers but at the same time using and producing cultural or conceptual artefacts. The inquiry process happens in trialogues through developing these mediating artefacts and practices.

Similarly sign processes can be interpreted anew from the trialogical perspective if it is taken into account that human beings are able jointly to produce external representations and signs to be re-interpreted by others (see Skagestad 1993). We are not just interpreting signs but also producing signs as external representations with others to be interpreted and modified in the future.

The line between dialogues and trialogues, and similarly with the participation and knowledge-creation metaphors of learning, is not, then, absolute. If people are, for example, producing a joint research paper, the trialogical work with the text and dialogical commenting and discussion about it intertwine a great deal. Still there is a clear difference in the emphasis with these two basic frameworks.

The trialogical approach can be used as a heuristic tool to highlight certain aspects of collaborative learning and work. The aim can be to transform existing practices of learning from "monological" (starting from individualistic learning), and "dialogical" (highlighting such things as participation to expert like practices, communication, dialogues) towards more trialogical ones (joint work around shared objects and practices supporting this work). How and if these transformations are possible is a practical question concerning pedagogical practices but also a theoretical question concerning ways of conceptualizing the aims and means of human learning

and cognition in general, and within particular pedagogical models. We have maintained, for example, that the *progressive-inquiry model* (Hakkarainen 1998; Muukkonen et al 2004) developed in our research group has been transformed from having aspects from the acquisition perspective (emphasizing conceptual problems, and conceptual scaffolds) towards the participation perspective (emphasizing social and cultural aspects and practices supporting inquiry processes). Currently, we are struggling to understand progressive-inquiry learning as a form of trialogical activity focused on practices of collaboratively advancing a shared object of inquiry, whether it is a research problem, theory, plan, product, practice (to be transformed), or project. This endeavor requires theoretical and conceptual development and corresponding improvements of research methods and methodologies in line with the trialogical approach.

4 Affordances for trialogical technology

A trialogical approach puts joint work around knowledge practices and knowledge artefacts to the front. This framework has profoundly affected by the emergence of ICTs that transform intangible ideas to shareable digital artifacts. What kind of role does such epistemic technology play in trialogical processes? Human beings have taken part in activities which can be interpreted as trialogical since the beginning of their very history (Donald, 1991; Vygotsky, 1978). By relying on conventional writing, visualization, and manufacturing instruments, they can develop knowledge artefacts and practices jointly and systematically. Yet, when addressing information and communication technologies, investigators have for long emphasized (as the term itself says) either information genre or communication genre with monologues and dialogues as respective social activities (Enyedy & Hoadley 2006). Further, theories on knowledge creation have not paid sufficient attention to the role of epistemic technologies in human activity.

While advancement of open-source development communities, for instance, highlight potentials of ICTs to facilitate collaborative or distributed creativity in the trialogical sense, ICTs have too often been addressed as something that either allows delivering study materials or opening up networking and communication possibilities. The success story of Wikipedia is also strengthening the belief about the influence of

new technology in knowledge-creation processes. Such approaches can be interpreted as forms or at least nearby phenomena to trialogical processes. Trialogical activities are supported by appropriate technologies that help the participants to create and share, elaborate and transform, organize and visually model diverse epistemic artifacts in conjunction with making visible, reflecting on, and transforming knowledge practices. Technology as such is no guarantee of trialogicality but it can give affordances for fluent and organized joint work with knowledge artefacts and practices. As we see it the trialogical approach requires that theoretical ideas, novel pedagogical practices, and technology development are developed together; these changes go together. Also outside the CSCL community (and related communities making research on collaborative technology) the role of technology to enhance distributed creativity is more and more recognized (e.g., Miettinen 2006).

In a large, five-year (2006-2011) EU-funded *Knowledge-Practices laboratory* (*KP-Lab*) project, the aim is to develop technology to support forms of trialogical learning (*http://www.kp-lab.org*). Theoretical conceptions of trialogical learning have provided directions and ideas for transforming existing pedagogical practices towards more trialogical knowledge practices, and for developing related technology. Basic characteristics of trialogical learning were defined at the beginning of the KP-Lab project. They were formulated on the basis of analyzing basic features in theories representing the knowledge creation metaphor of learning (Paavola et al. 2004), and using previous experiences of developing learning environments, and in relation to pedagogical aims of the project. The knowledge creation metaphor of learning transforms many old dichotomies concerning learning theories, such as individual vs. community, concepts vs. situations, theory vs. practice (ibid.). The following *design principles* (DPs) were then formulated characterizing the general features of the trialogical learning:

DP1) Organizing activities around shared "objects": A central idea of trialogical learning is that work and learning are organized around developing shared, concrete objects, that is, conceptual artefacts (e.g., ideas, plans, models), concrete, material products (e.g., prototypes, design artefacts) and/or practices (e.g., ways of working in higher education).

DP2) Supporting interaction between personal and social levels: People integrate their own personal work and group's practices and resources for developing shared objects, combining participants' expertise and contribution into the shared achievement.

DP3) Eliciting individual and collective agency: Trialogical learning has its basis on epistemic agency of the participants; both agency of individual participants in their own efforts, but also collective agency supporting social processes and collaborative efforts. (This design principle comes close to the previous one, and was actually merged to it in later lists of design principles).

DP4) Fostering long-term processes of knowledge advancement: Trialogical learning requires sustained, long-standing work for the advancement of the objects of inquiry.

DP5) Emphasizing development through transformation and reflection between various forms of knowledge and practices: An interaction and transformations between tacit knowledge, knowledge practices, and conceptualizations are a driving force in processes of knowledge creation.

DP6) Cross fertilization of various knowledge practices across communities and institutions: Knowledge work in KP-Lab engages people in solving complex, authentic problems and producing objects also for purposes outside the educational institution; An essential aspect of the KP-Lab project is hybridization between schooling/studying and research cultures as promoted in various investigative learning practices.

DP7) Providing flexible tool mediation: Trialogical learning cannot easily be pursued without appropriate technologies that help the participants to create and share as well as elaborate, reflect and transform knowledge artefacts and practices. Novel collaborative technologies should provide affordances for trialogical learning processes.

These design principles themselves have been evaluated and updated during the project. They must be interpreted and used somewhat differently in different pedagogical contexts (see Ilomäki & Paavola 2008). The challenges and possibilities to develop trialogical practices, for example, at research seminars for educational fields at the universities are somewhat different than in design courses for engineers at the universities of applied sciences, but both can use quite similar technology and benefit from "cross-fertilizing" their ways of working. KP-Lab project's technological design can be examined from the perspective of four *types of mediation* which have been used

for specifying the above mentioned design principles to the general aims of the technology development. These types of mediation are reformulations of the ones introduced by Rabardel and Bourmaud (2003), i.e., *epistemic mediation* related to creating and working with knowledge artefacts, *pragmatic mediation* related to organizing and coordinating knowledge-creation processes, *collaborative mediation* concerning building and managing networked communities and social relations required for carrying out knowledge-advancement efforts, and *reflective mediation* in terms of making visible, reflecting on, and transforming knowledge practices. The system is designed, then, to support *multimediation* by providing a shared knowledge space that facilitates all four modes of mediation, and the flexible use of them together.

This paper has, however, concentrated on delineating the theoretical background to the meaning of trialogues, or trialogical learning; pedagogical research and development (see e.g., Muukkonen et al., in press), and technology development with object-bound emphasis (see e.g., Lakkala et al., in press; Paralic & Paralic 2007; Furnadziev et al. 2008) are not the focus in this paper.

5 Conclusion

The trialogical approach is actually not so much a specific theory as a framework that assists in facilitating sustained collaborative efforts of developing shared objects. In this regard its epistemic status resembles that of the dialogical framework. It is possible to create various kinds of (research) approaches around such a framework. You may always ask to what extent an approach to CSCL, whether it is related to problem-based, project-based or design-based learning, share "trialogical" characteristics and how it could be improved in this regard. The present investigation highlights the importance of complementing the meaning making tradition with a joint construction of shared "trialogical" artefacts and practices. More elaborate models, tools and theories are under (trialogical) construction!

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