Developing and applying design principles for knowledge creation practices

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A general introduction

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Learning sciences, especially when connected to developing new educational technology, have characteristics of *design sciences*. It can be argued that design sciences require methodological and theoretical outlook which differs from traditional models of science (Simon 1997). One central way of developing new methodological solutions is the use of *design principles* to guide the design of educational practices and technology. Various ways of developing design principles have been suggested, both top-down, i.e. theory driven (e.g. Scardamalia 2002; Kaptelinin at al 1999), and bottom-up, i.e. empirically informed (Kali 2006; Arnseth & Ludvigsen) approaches.

This symposium discusses the role of design principles, and analyzes their uses in a research and development project, KP-Lab (Knowledge Practices Laboratory; see www.kp-lab.org). The KP-Lab project is a large, five-year project supported by EU, aiming at developing and making research on the "trialogic" knowledge practices and technology, and what can be called *knowledge creation metaphor* of learning (Paavola et al. 2004). The trialogical approach aims at understanding how people collaboratively, in long-term processes, develop novel epistemic things and transform their knowledge practices in education and at workplaces, and how students in higher education act similarly by cross-fertilizing professional and educational practices and solve complex, authentic problems with the help of innovative knowledge practices and educational technology.

The aim of the KP-Lab project is to develop the trialogical approach to learning and related pedagogical scenarios and technology. In order to do that, general design principles have been developed based on theoretical models concerning collaborative knowledge creation processes as well as experiences of research on collaborative learning environments. These design principles illustrate the general characteristics of the trialogical approach on learning, but they are re-evaluated and refined during the project. In this symposium, we will continue the discussion about design principles, the definitions, focus and scope. The following central design principles (DPs) were defined at the beginning of the project to describe trialogical learning:

DP1. Organizing activities around shared objects: a central idea of trialogical learning is that work and learning are organized around developing shared knowledge objects;

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

DP3. Eliciting individual and collective agency: the responsibility for creating shared new knowledge objects is shifted from educators to learners;

DP4. Fostering long-term processes of knowledge advancement: trialogical learning requires sustained, focused work on topics of interest;

DP5. Emphasizing development through transformation and reflection between various forms of knowledge and practices: declarative, procedural as well as tacit knowledge and practices are externalized, reflected, conceptualized and transformed during the process;

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;

DP7. Providing flexible tool mediation: knowledge creation should be supported by dedicated tools for mediating collaborative activities and enhancing aspects highlighted in the other design principles

We describe, first, the development of design principles in the project in a theoretical paper, and then the use and development of these principles for analyzing and implementing knowledge-creation type of activity in

three educational contexts. The focus is on collaborative knowledge practices and on the role of technology to support them. The special emphasis is on the methodological implications for using and developing design principles, in interaction between the theoretical approach and the empirical findings.

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Design and evolution of design principles for knowledge creation – The dynamics of theory and practice

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In our presentation we describe how design principles for the *trialogical approach* to learning were developed and formulated during the early stages of the KP-Lab project, and an overall methodology related to this development. The trialogical approach aims at developing pedagogical models, novel practices and tools for organizing learners' activities around shared, novel objects (like texts, conceptual artifacts, digital/computational artifacts, multimedia products, practices) that are created for some meaningful purpose and subsequent use. A background for this approach can be found on the knowledge building approach (Bereiter, 2002), and on the experiences of developing and doing research on collaborative learning environments, but broadening these approaches with socio-cultural perspectives (e.g. Engeström, 1987); in short, on models representing the so-called knowledge-creation metaphor of learning (Paavola et al., 2004).

One challenge for the KP-Lab project has been that it builds on the idea that also the theoretical framework (the trialogical approach on learning) will be developed during the project. This is typical for the design-based approach; in the KP-Lab project not only practices and tools but also the theoretical approach is emerging. The aim is to produce innovations also theoretically because along with novel knowledge practices and new technology the theoretical conceptions must be developed. There is no ready-made theory for understanding technology mediated trialogical processes. The trialogical approach is an 'epistemic object' (Knorr Cetina, 2001), that is, an open-ended knowledge object which is defined in more detail during the project. The work with these kinds of epistemic objects requires a new kind of methodological solutions also in relation to the theory development.

How then to formulate design principles for something which does not yet exist (in our case, a full-blown conception of the trialogical approach to learning)? Candidate solutions are either to start from some framework or theory (which is implemented in practice) and with the help of that derive (deductively) design principles for that kind of a framework, or to try to derive design principles inductively from existing knowledge practices (cf. Arnseth & Ludvigsen, 2006). Both approaches in themselves are, however, problematic if the aim is to capture and develop new innovative knowledge practices and tools. A theory-driven approach aims at implementing existing theoretical ideas and is not sensitive to new, emerging practices nor to problems of practical implementation of theoretical ideas. A practice-driven approach easily confirms already existing practices, and do not necessarily provide good basis for new design ideas, or emergent practices.

We analyze tensions with a project like KP-Lab between a "theory-driven" and a "practice-driven" approach towards an overall knowledge-practices oriented methodology for the project, and study how these tensions are solved or handled. Designing new technology requires conceptual understanding and powerful abstractions of those knowledge practices which are supported with new technology. On the one hand, this kind of a conceptual understanding is the result of the research on emerging knowledge practices. We analyze the KP-Lab methodology as such an abductive process (see Paavola, 2006) where theories and conceptualizations are not produced primarily for the purpose of testing them, or for the purpose of explaining things, in a strict sense, but in order to guide further activities like the design of tools and the promotion of innovative practices. This kind of a methodology focuses on the dialectics between theory and practice. On the one hand, theory-informed design-principles and first versions of trialogical approach have given guidance to ways of framing trialogical knowledge practices and the development of supporting tools. On the other hand, knowledge practices of real cases have then informed the specification and modifications of design principles. We analyze how this kind of a design approach can be seen in relation to other design approaches like participatory design, and theory-based or theory-informed design especially from the point of view of theory development.

In the end we present a trialogical "checklist". The basic idea of a "checklist" is borrowed from the "Activity checklist" (see Kaptelinin et al., 1999). This checklist has its basis on a framework describing basic features of *activity theory*, and how they can help to focus questions concerning design and evaluation of tools from the perspective of activity theory. Analogous, KP-Lab design principles provide a basis for a trialogical checklist but instead of producing a checklist for human-computer interaction in general, which is the aim of the Activity checklist, it aims at specifying a checklist for collaborative knowledge practices for developing shared artifacts and practices further. It specifies central aspects and guiding questions of technology and pedagogical design and evaluation for the trialogical approach to learning, and has been produced within the KP-Lab project on the basis of theory informed design principles and empirical findings concerning their use.

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Conceptual mapping as a form of trialogical learning intervention

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Collaborative conceptual mapping of complex, multifaceted or ill-defined phenomena plays a prominent role among pedagogical methods used in higher education. It opens an opportunity to share responsibility in collective efforts to capture the meaning of central concepts and essential relations in the target domain of learning. Collaborative conceptual modelling in its core can be characterized as a pedagogical method, which has technical, social (Patterson, Dansereau, & Newbern, 1992) as well as epistemological and cognitive dimensions (Farrand, Hussein, & Hennessy, 2002; O'Donnell, Dansereau, & Hall, 2002). It supports object centred inquiry, development of critical thinking skills and social sharing of knowledge by allowing participants to construct various conceptual relations around target phenomena (Nesbit & Adesope, 2006). Collaborative conceptual mapping can be a practice that supports knowledge creation metaphor (Paavola, Lipponen & Hakkarainen, 2004) and trialogical learning.

In the present study, collaborative conceptual mapping was investigated as an activity embedded in a pedagogical practice. We focused on investigating how design principles can be used in analysing collaborative conceptual modelling in a higher education course. The creation of concept maps was not a goal itself but as an intermediate part of an overarching learning activity. Research questions addressed in the study were the following: 1) How were the central principles of the trialogical approach realized in the students' collaborative conceptual mapping activities and their outcomes; and 2) How were the technical tools used to mediate the collaborative conceptual mapping activity and what recommendations can be made to develop the tools further?

Setting

The investigated course was voluntary for students at the Department of Psychology. It acquainted the students with qualitative research methods as well as provided them with support for the advancement of their master thesis. The course was a combination of face-to-face meetings with students' presentations and discussions, work in pairs for constructing concepts maps (with CMap-Tools, see http://cmap.ihmc.us/) during the meetings and students' own time, and students' preparatory work before the meetings, working also through a virtual collaboration tool Future Learning Environment (FLE3, see http://fle3.uiah.fi). The schedule for the course was launched on the basis of this initial discussion and expressed problems, related to the student's own research interests.

During the course, the participants prepared a presentation on their own theme so that presentations were held in each meeting throughout the course. Each meeting was organized around a one issue so that those students that were interested in the same theme had their presentations in the same meeting. The concept maps were re-organized and re-written after each course meeting on the basis of the new information encountered by the participants as well as shared through FLE. Between the meetings, the participants were supposed to keep track of the FLE environment of the course, insert there their own comments as well as supplementary materials. The last meeting focused on the results of the course. Concept maps were compared and discussed; the situation of students' own work was discussed and the general results of the course were evaluated.

Methodology

The data collected from the case consisted of teachers' written teaching logs, sent through e-mail; students' written self-reflections after the course; as well as the contents of the database in FLE3 systems, including the successive versions of students' concept maps. The activities in the course were reconstructed from the participant's descriptions and the database structure and contents, using an investigative approach that may be characterized as exploratory case research (Yin, 2003). Various data sources and analysis methods were combined, in order to provide a multi-faceted and comprehensive picture of the course practices and the use of tools.

Results

The results of the study indicate that the conceptual mapping activity served various purposes in the students' activity, considered from the perspective of trialogical approach on learning. First, it created a concrete *shared mediating object* for collaborative working. Collaborative conceptual mapping allowed the student pairs to explicate for each other their conceptions of the abstract and intangible topic of the course, qualitative research methods. The collaborative creation of shared external representations can be concluded to *mediate the interaction between individual and social levels* because their creation required the students to share their ideas and also to mirror the outcomes with their own understanding. The maps supported *the transformation and reflection between various forms of knowledge* because the students were able to, first, explicate their previous understanding into the first versions of the maps, and then elaborate the maps based on the new knowledge provided by other students' presentations and teachers' explanations. The iterative updating of the conceptual maps served *long-term knowledge advancement*. Each student pair produced 2-4 versions of their concept maps during the course; according to preliminary analysis the level of, coherence and scientific accuracy of the concept maps increased. *Flexible tool mediation* was partly actualized by the CMap-Tool that has sophisticated functionalities to support conceptual modeling; it was itself easy to use but to save the produced maps to university's system or uploading them into FLE3 was difficult. It turned out that the integration of various technical tools simultaneously did not succeed very well. More detailed results are presented in the symposium.

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From design principles to educational practices: a project in secondary education

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Introduction

The knowledge creation approach to learning (Paavola, Lipponen and Hakkarainen, 2004) proposes a reconceptualization of the way in which learners and institutions organize knowledge work. This approach depicts learning as a collaborative activity aimed at creating *new* knowledge. The design of educational settings that applies these innovative ideas involves the development of new pedagogical methods and technological tools, based on design principles grounded in the knowledge creation approach on learning.

In the current proposal we present a design-based approach to implement a number of principles, derived from the knowledge creation perspective of learning, in the context of a secondary school (UniC) in the Netherlands. UniC's pedagogical vision is characterised by the encouragement and the support of the students' personal development and interests as a basis for learning. In addition, UniC stimulates collaboration between students and meaningful learning. Both the school's and the researchers' interests in developing empirical support for the effectiveness of this approach constituted a potentially fruitful ground for collaboration. The results obtained from studying students' and teachers' practices will feed back into the continuous iterative development of the design principles. Also, the results will provide a new insight into the way knowledge creation is enacted within this specific context, and will lead to suggestions to improve our approach in practice.

At UniC, a multi-disciplinary team consisting of these researchers, teachers, students, dean, and external experts was set-up aimed at the redesign of this learning module based on principles of the knowledge creation metaphor, which was found to match UniC's general pedagogical approach and aspiration. These principles are not a unified list of ideas that can be built into any educational setting. Some of them are useful as guiding ideas for the construction of educational scenarios; others are more like emergent consequences of the implementation and enactment of knowledge creation. Generally speaking, the principles can be seen as an evolving set of general guidelines to be adapted to situational demands. The principles that were employed are: (1). Trialogical activity around shared objects, (2) Interaction between the personal and social levels, (3) Cross-fertilization of knowledge practice, (4) Flexible tool mediation for trialogical activity, (5) Development through transformation and reflection.

Aim of this study

In this study we attempt to gain more insight into the practices relating to the implementation of design principles that are based on the knowledge creation perspective on learning in a particular educational context. We aim at investigating how the design principles can be built in collaborative work in a functional manner and what the implications are for the various actors involved in this design project.

Methodology

The approach we employed in this study is a combination of design-based research (Brown, 1992; Collins, Joseph, & Bielaczyc, 2004) with qualitative analysis methods. An existing learning module with a duration of eight weeks was re-designed using the design principles as conceptual tools. Several weeks before this module would commence, project partners had several meetings to get acquainted with each other, pedagogical approach and

practices at UniC and with the design principles of knowledge creation. In addition, a preliminary curricular approach was taken to guarantee a high-quality implementation start of the project at UniC, also by involving both students and their parents. During the project partners organized several informal meetings which served to improve the design of the learning module based on experiences of teachers and researchers encountered during implementation of the module and based on the design principles. To accomplish this aim, the multi-disciplinary team at UniC had to create conditions for reflecting on and advance their practices in face of the interchange between the different modes of knowledge. The ultimate goal this community wanted to achieve was that students would create their own knowledge during technology-supported authentic projects in which they collaboratively work in small groups around knowledge object.

The new design of the module was introduced to twenty-nine students and to their parents, during an introductory meeting. Students formed 8 groups of three or four, based on preferences for a certain topic. Six of the groups envisioned objects for which they gained the interest of internal or external stakeholders. In a final session, students had to present their results to the stakeholders, the other students, teachers, and researchers. Technological support was provided by FLE3 (Future Learning Environment), which was introduced during a demo session in the first module session. Qualitative data obtained from verbal transcripts and observations were analyzed employing a multiple-method approach, which involved content analysis of the discussions and interviews, analysis of documents produced by students and a context analysis for describing the pedagogical and institutional context. Central in the analyses was how the design principles were actualized at the level of student and teacher practices.

Results

Principle 1 (focus on shared objects): A diversity of objects was created throughout the module. As the module progressed, it became clear that simply stating the final object was not enough for it to be the focus of the group. Groups had to actively concretise their object. Teachers identified and acknowledged the need for object-relatedness of students' practices and consequently started to focus on the object in their guidance of student groups.

Principle 2 (personal and social levels): The shared nature of the object directed groups towards employing collaborative activities and engaging in an intensive interaction. Although groups often divided tasks between students, an essential next step was sharing the results of these individual actions with the other group members. Only then could they be used to further develop the shared knowledge object.

Principle 3 (cross-fertilization): There are various interpretations of the concept of authenticity in education. In our case we introduced the concept of the client or other stakeholders, who besides the teacher, was interested in employing and further advancing the groups' product. These cross-boundary activities were both motivating for students but also created gap closing tensions.

Principle 4 (technology): Groups used FLE3 predominantly as object repository, storing background information, preliminary and final objects into their group space. Although teachers were allowed into the groups' space, they did not utilize this functionality.

Principle 5 (knowledge transformation): Several features of the module contributed to the occurrence of observable transformations. These transformations concerned, on the one hand, the conceptualisation and perception of the shared object and, on the other hand, transformations with regard to ways of working related to the development of the object. Both external influences (such as the client), as well as groups' emerging insights contributed to the occurrence of these transformations.

Conclusion

What occurred at UniC can be called practice bound hybridization of concepts (i.e., design principles) borrowed from the knowledge creation model. Since collaborative design practices at UniC will take place longitudinally, spanning several modules, the school can be advised and supported based on the results reported. Regarding the redesign of the learning module according to the design principles, the outcomes indicate that the educational practice was enriched by the interplay of design principles and experiences obtained from their implementation. At this point, the project team is able to move forward and learn from the issues that are raised above and achieve more focus on shared objectives. Further implication of the results, and the way these results feedback both into the redesign of the course and development of the design principles will be discussed.

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Turning Debriefings into Knowledge Creation Practices

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Introduction and Background

The KP-Lab project seeks to understand how people create knowledge and transform their practices by developing and advancing common objects of activity (Paavola & Hakkarainen 2005). Its "trialogical" approach suggests a new metaphor of learning which can influence the design of educational settings and tools. We report results from a specific educational context: medical simulation training of interprofessional teams involved in critical care. Such training usually involves a debriefing component following participation in simulations in which participants receive feedback on their performance. These are often viewed as an essential, or even the most important, part of simulation courses (DeVita *et al* 2005, Harrison & Gaba 2005). Merely taking part in and practicing in simulations is not enough (Satish & Streufert 2002), or as Beaubien & Baker (2004) put it, "Perfection can only be achieved through practice with feedback". Therefore, in simulation courses more time is often spent on giving feedback in debriefings than on the simulations themselves.

In the literature, debriefings are often described as situations where feedback is something that participants "get" from instructors (Østergaard *et al* 2004), or something that participants are "provided with" (Baker *et al* 2005, Gaba 2004). Feedback information about "any lacking competency is communicated to trainees" (Satish & Streufert 2002). Such descriptions seem to imply that the role of the participants is that of a passive recipient of feedback information and observations from instructors.

A related issue concerns assessment of medical teamwork which in general is carried out by especially trained observers or "teamwork experts" rather than practitioners themselves (Shapiro *et al* 2004, Thomas *et al* 2007, Weinger *et al* 2004). There are practical and methodological reasons for this, nevertheless, our goal has been to support course participants in becoming better at doing own analyses and assessments of team performance.

Aims of the study

Our aim has been to support course participants in actively participating in doing observations and analyses of teamwork and communication processes during post-simulation debriefing sessions using video recordings. In attempting to reach this aim we investigate how trialogical design principles can be used to design conditions for such activities during debriefings.

Methodology

New practices, a conceptual tool, and, software have been designed with inspiration from a knowledge-creation metaphor of learning and the design principles. The trialogical approach to learning has suggested a group of design principles (DPs) of which the following will be primarily discussed: DP1: Focus on trialogical activity around shared objects; DP2: Interaction between personal and social levels; DP5: Development through transformation and reflection between various forms of knowledge

The proposed practices and the conceptual tool have been introduced in a simulation course. Various data sources and analysis methods have been combined including intensive questionnaire data collection during courses and interaction analysis of video recordings from simulations and debriefings to study qualities in use that the designs may bring about.

Discussion

Focus on Trialogical activity around shared objects. An objective was to encourage course participants in becoming engaged in doing observations and creating analyses of the performance of the teams in the simulations.

The courses were designed so that participants would iteratively analyze their performance in the simulations and means were taken to make the analyses more explicit by providing shared conceptual tools for this purpose. Efforts were made to focus course participants' reflection and discussions about exercises on a number of key issues by providing a model specifically designed for this purpose. Introducing the model as a starting point for observations, reflection, and analysis reminded participants about the central issues and structured their discussionsAt some point they now needed to relate to the categories of the model which thereby appeared to structure discussions and the model ensured that participants addressed issues which otherwise risked being overlooked

Interaction between personal and social levels. To make all participants more active, we modified and extended the debriefings: participants first did individual analyses after each simulation followed by analyses with the team which finally attempts to reach agreement. Interesting discussions and negotiations took place when the participants discovered that they had differing observations or opinions when trying reach a common understanding.

Development through transformation and reflection. The courses began with lectures and then certain activities were iterated over and over again; first a simulation, then a debriefing session, and finally a video session. During simulations there was minimal time for analysis but afterwards participants were able to spot unnoticed incidents and behavior on the video recordings and discuss these lengthily. To address the challenge of further supporting transformations between theoretical knowledge, practices and "tacit" knowledge, knowledge-practices were created where each individual course participant assessed a number of aspects of teamwork and communication issues by continuously scoring their own as well as the entire team's performance.

The knowledge-creation metaphor and the trialogical design principles have inspired by highlighting certain aspects rather than others and gave valuable hints about in which direction the design and development of educational practices should proceed. Emphasis was put on knowledge creation activities: the participants were encouraged to actively engage in making observations and creating analyses about teamwork and communication rather than just being recipients of feedback. The course instructors are experts in these knowledge practices, but instead of handing over all responsibility for such analyses to them, the participants were encouraged to participate.

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