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Investigating knowledge creation technology in an engineering course

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ABSTRACT

The aim of the present study was to examine the technological affordances of a web-based collaborative learning technology, Knowledge Practices Environment (KPE), for supporting different dimensions of knowledge creation processes. KPE was used by engineering students in a practically oriented undergraduate engineering course. The study concentrated on students' usage and selfreported experiences of the tool, and student-adopted strategies for spatially arranging items in KPE's main knowledge space. According to the results, students used KPE mainly to share and organize project documentation. KPE appears to offer an advantage over traditional folder-based learning environments by providing a structured visual overview of the process and materials in the content view, thus facilitating pragmatic and epistemic dimensions of knowledge creation at the same time.

1. Introduction

New educational technology provides challenges but at the same time potentialities to develop working practices in higher education. The emphasis on knowledge work in modern society requires new kinds of competencies also from students: knowledge workers should be able to collaboratively produce new knowledge and manage increasingly complex knowledge artefacts (Knorr Cetina, 2001; Muukkonen, Lakkala & Paavola, 2011). At the same time, modern collaboration technology requires and enables novel practices of working with knowledge. This development presents requirements for collaboration technology in educational settings: it should provide students with *affordances* (Norman, 1988) for creating and developing new knowledge together and for practicing the skills and competencies of collaborative knowledge work in general.

The present study focuses on the role of technology in facilitating knowledge creation practices during an engineering education course aimed at collaboratively designing a product or solution for a real customer. Engineers designing multimedia products face various challenges posed by innovative technological solutions and a more collaborative way of working (Denton & McDonagh, 2005; Marttiin, Nyman, Takatalo, & Lehto, 2004). A theoretical background of the study was provided by the so-called *knowledge–creation approach* to learning (Paavola & Hakkarainen, 2005) which focuses on learning as a collaborative process of advancing and producing shared objects, like documents, practices, and product designs. This approach to learning is called 'trialogical' because it emphasizes the role of shared objects produced instead of concentrating on individuals' learning (a monological approach) or interactions between people (a dialogical approach).

The learning technology under investigation, Knowledge Practices Environment (KPE), has specifically been developed in an attempt to support aspects of knowledge creation processes that are typically not well supported by existing virtual learning environments (VLEs) used by educational institutions. Investigating KPE in a practically oriented engineering course is especially fruitful, because students face complex problems akin to real-world challenges: addressing the ill-structured task of designing a product for a customer, planning and coordinating tasks and processes, dealing with the work load and a division of labor, and sharing and versioning multiple design artifacts.

2. Technological affordances for collaborative knowledge creation

Introduction of new ways of working like distributed team work, increasing emphasis placed on producing new knowledge as well as recent sociotechnical innovations like wikis and weblogs have driven knowledge workers to adopt new practices of working with

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knowledge. At the same time, the concept of knowledge has been changing: researchers have started characterizing shared knowledge as open-ended and in process of being defined by the participants, i.e. as 'epistemic objects' (Knorr Cetina, 2001).

Similarly, many theoretical approaches to technology-enhanced learning have been proposed and elaborated during the last 15–20 years. The dominant approaches in so-called Computer-Supported Collaborative Learning (CSCL) highlight the social and interactional nature of learning, bringing argumentation and dialogs between participants to the center (Andriessen, 2006; Stahl, Koschmann, & Suthers, 2006). In those approaches, the main focus has been on individual students' learning of certain domain content or skills, which the technology-supported collaborative activities promote. The interest in the present study, instead, has been to accustom students in expert-like knowledge creation practices with the support of appropriate technology, especially in collaborative designing of real products. The theoretical background of the study, the so-called *knowledge–creation approach* to learning (Paavola & Hakkarainen, 2005) emphasize knowledge artefacts and ways of working as objects of learners' activities, something that can be created, improved and re used together. Examples of similar theoretical approaches are the knowledge building approach (Bereiter, 2002; Scardamalia & Bereiter, 2003), the progressive inquiry model (Muukkonen, Lakkala, & Hakkarainen, 2005) and the theory of expansive learning (Engeström, 1987). A common feature of these approaches is that they emphasize the role of *mediation* and the *object-oriented* nature of human activity. The knowledge creation approach aims at supporting both the joint work with knowledge artefacts (i.e. epistemic issues), but also processes and practices supporting collaborative activities. We maintain that students should be accustomed to challenging, collaborative knowledge creation practices throughout their studies for learning to implement and organize these kinds of processes in versatile ways.

Despite technological and theoretical advances, many existing virtual learning environments have been designed to support well-defined, teacher-led activities in instructional settings rather than new organizational practices like virtual team work (Ballesteros, 2006). Sharma and Fielder (2004) argued that current course management systems like Blackboard are built to anticipate and control the instructional environment, not to support open-ended and self-organized learning activities. Creating closed systems that are bound to an educational institution hinder sustained and inter-contextual learning activities (Attwell, 2007; cp. Wilson et al., 2006). Educational field has a demand for learning environments that take into account the open-ended, changing nature of knowledge artefacts and the chaotic nature of knowledge work that often needs to cross boundaries between individual settings, groups and institutions.

To characterize the types of technology mediation required to support open-ended and often chaotic knowledge creation processes, we reformulated Beguin and Rabardel's (2000; see also Hakkarainen, 2008) four types of technology mediation: epistemic, pragmatic, social and reflective. Our view of technology mediation is similar to Beguin and Rabardel's: we see the instrument mediated activity as a combination of psychological, social, and technical aspects. Technological functionalities can provide affordances but it is the way of using them that makes them effective instruments. The present investigation examines the types of affordance KPE offers for the knowledge creation process. The focus is primarily on epistemic and pragmatic mediation, because functionalities intended to support social or reflective mediation were not fully available at the time of data collection. The four types of mediation are shortly defined below (see also Lakkala et al., 2009).

Epistemic mediation refers to tools, features and functionalities that support work with knowledge artefacts that take the form of texts, images, audio and video. Specifically, they mean functionalities that help create, transform, organize and flexibly link knowledge artefacts together. They also support negotiation and commenting on the artefacts when a group of people is working on them together and provide functionalities that facilitate the development and co-editing of shared artefacts. Supporting work with knowledge artefacts is the core idea of the knowledge creation approach but it is not enough in itself. With KPE this is achieved, e.g., by attaching comments and discussion to knowledge items instead of separating knowledge artefacts and discussion from each other.

Pragmatic mediation refers to tools, features and functionalities that help organize and manage knowledge creation processes and work with knowledge artefacts. Devices that help plan, organize and coordinate tasks, work processes and task responsibilities belong to this group as well as flexible means of updating and revising these plans and processes. With KPE, pragmatic mediation is promoted, e.g., by giving users the possibility to access the shared working space from the perspective of tasks in a process view. It is also possible to view knowledge artefacts and tasks in the same view so as to see their relationship with each other, which integrates epistemic and pragmatic mediation.

Social mediation refers to tools and features that offer support for managing social relations during the knowledge creation process, such as social networking, community building and interaction around shared knowledge artefacts. *Reflective mediation* refers to tools and functionalities that support reflection on work practices or processes, meaning that knowledge practices and processes can be taken as objects to be collaboratively analyzed and developed. Ultimately, Knowledge Practices Environment (KPE) is designed to support *multi-mediation* by providing a shared knowledge space that supports all four types of technology mediation (Markkanen et al., 2008).

In order to clarify the particular design solutions made for developing the KPE system for effectively mediating knowledge creation processes, we briefly compare it with technology solutions typically used in VLEs. Concerning epistemic mediation, most VLEs in use today (e.g., Moodle, BSCW, Blackboard, or FLE3) use hierarchical folder systems where knowledge artefacts remain isolated with weak support for explicating relationships between them, rearranging them, or revising them in a sustainable way. For supporting social interaction, existing VLEs usually include separate threaded discussion forums and chat tools that are difficult to combine with work on knowledge artifacts. Some learning environments include spatial views, modeling tools and concept maps for working with external representations of knowledge (e.g., Knowledge Forum or CMap-Tools), but those tools do not include functionalities for planning and coordinating processes or integrating social interaction, knowledge artifacts, and processes in a flexible way. Instead of folder-based systems, KPE users manage their knowledge artefacts by spatially arranging them in shared knowledge spaces that also include integrated tools and functionalities for social interaction and practical coordination of activities.

Because a special feature of KPE is the possibility to manage collaborative processes and shared knowledge spaces through modifiable and expandable spatial views, it is important to investigate how students use spatial arrangement during a complex real-world design project. In the present study, students' usage of spatial arrangements to manage knowledge artefacts and processes in a virtual learning environment is examined and characterized by using David Kirsh's thinking about the role of visual design in VLEs. According to Kirsh (2005), the visual design (including spatial arrangements) supports users' metacognition, i.e. activities and skills that are related to planning, monitoring and correcting processes that occur in virtual learning environments.

Kirsh proposes three ways of spatially arranging items in external environment to improve task execution (1995). The three ways Kirsh mentions are 1) using spatial arrangement to simplify choice, 2) using spatial arrangements to improve perception and 3) using external