TECHNOLOGY ENHANCED LEARNING

Collaborative Knowledge Creation

Practices, Tools, Concepts

Anne Moen, Anders I. Mørch and Sami Paavola (Eds.)

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Scope

The rapid co-evolution of technology and learning is offering new ways to represent knowledge, new educational practices, and new global communities of learners. Yet the contribution of these changes to formal education is largely unexplored, along with possibilities for deepening our understanding of what and how to learn. Similarly, the convergence of personal technologies offers new opportunities for informal, conversational and situated learning. But this is widening the gulf between everyday learning and formal education, which is struggling to adapt pedagogies and curricula that were established in a pre-digital age.

This series, *Technology Enhanced Learning*, will explore learning futures that incorporate digital technologies in innovative and transformative ways. It will elaborate issues including the design of learning experiences that connect formal and informal contexts; the evolution of learning and technology; new social and cultural contexts for learning with technology; novel questions of design, computational expression, collaboration and intelligence; social exclusion and inclusion in an age of personal and mobile technology; and attempts to broaden practical and theoretical perspectives on cognition, community and epistemology.

The series will be of interest to researchers and students in education and computing, to educational policy makers, and to the general public with an interest in the future of learning with technology.

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PREFACE

The book is about collaborative knowledge creation, and more specifically about the *trialogical* approach to learning. Throughout the book, the authors explore collaborative work with shared knowledge artefacts and objects, and relate their contributions to tool development for and practices of technology-mediated learning. The contributions are concrete examples to explain how people create knowledge that is materialized in concrete objects, and transforms their knowledge practices by cross-fertilizing new and existing practices in educational and professional environments.

The book presents results from the Knowledge Practices Laboratory (KP-Lab) project (http://www.knowledgepractices.info), an EU-funded integrated project (2006–2011), to a broader audience. 22 partners from 14 countries joined to explore higher education courses, workplace learning and teacher training situations to help bridge practices in educational and professional institutions.

The book is aimed at readers interested in collaborative knowledge creation processes and technology-mediated learning. Compared to other contemporary European perspectives on technology-enhanced learning, the chapters in this book are framed within one overarching theoretical perspective, the trialogical approach, to explore knowledge creation processes.

As editors of this book, we are grateful to the authors' commitment to contribute and present their work here. It has been a long journey, starting as a workshop in Oslo in 2007, followed by several iterations from initial conception to completion. Thank you all for persistence in a long process.

In addition to the authors of the chapters, we would like to express our great appreciations for the contributions by the KP-Lab senior researchers, and the KP-Lab expert panel members Carl Bereiter, Yrjö Engeström, Erno Lehtinen, Sten Ludvigsen, and Gerry Stahl. Without your participation, feedback and advice this book would not have been possible. Thank you very much!

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Oslo/Helsinki, March, 1st 2012,

Anne Moen, Anders I. Mørch, Sami Paavola (editors)

ANNE MOEN, ANDERS I. MØRCH AND SAMI PAAVOLA

COLLABORATIVE KNOWLEDGE CREATION: INTRODUCTION

Understanding transformations of knowledge practices, both educational and professional, has been an overall goal in the explorations presented in this book. There is a need for new approaches to learning, especially for understanding and supporting practices where people are creating or developing useful and reusable things in collaboration. This assertion challenges several existing perspectives on learning: theoretically, pedagogically, when it comes to technology support, and when it comes to location (at school, at work, etc). Initial questions motivating our work included: What kind of knowledge practices, i.e. ways of working with knowledge, is needed in modern working life? How to teach and learn them? And what is the role of digital technology in these practices?

Collaborative knowledge creation seen in technology-mediated work with knowledge artefacts for practice transformations, and the *trialogical* approach to learning binds the chapters of this book together. The specific contribution of the trialogical approach is a combination of the conceptual aspects of the inquiry processes and idea-centred work with features adopted from the pragmatically- and 'materially' oriented approaches (Paavola & Hakkarainen, 2009).

Current approaches to learning emphasize issues like participation (Sfard, 1998), joint meaning making (Stahl et al., 2006), discourse and dialogue (Wegerif, 2006) as starting points for collaborative learning. As such, they also challenge individualistically oriented conceptualisations of learning. The same concerns technology and technology-mediated learning. 'Information media' has been challenged and supplemented with 'communication media', which are interfaces extending from human computer interaction to social interaction (or 'dialogues') (Enyedy & Hoadley, 2006). Furthermore, computer-supported collaborative learning environments complement and extend individual-oriented learning systems (Ludvigsen & Mørch, 2010). Notions like 'Web 2.0' are often used to point out new technology for harnessing participation, social networking and collective intelligence. We maintain that these perspectives' suggestions to extend single user environments to collaborative interaction are not by themselves sufficient to understand and support modern knowledge work. Supplementary approaches are needed to take into account collaborative, long-term, iterative work with concrete things and issues.

The 'objects' and 'artefacts' play a crucial role throughout this book. This is one key to understanding the trialogical approach to learning. The practical and theoretical importance of 'objects' and 'artefacts', and their characterization as collaboratively developed becomes central. Although these directions in the evolution of technology have existed for some time (Engelbart, 1962), the current opportunities are that the technology can try to 'catch up' with the early visions and conceptual frameworks. New kinds of object-oriented, or artefact-mediated approach carries a lot of unused potentiality, and should be further developed, harnessed, and applied, especially when it comes to technology mediated collaborative learning.

On one hand, and according to the *cultural-historical approach*, human activities are mediated by artefacts, used and modified by succeeding generations of humans and grounded in practical, everyday activities (Cole 1996; Miettinen & Virkkunen, 2005). Artefacts are seen more generally as the central means for cultural evolution (Wartofsky, 1979). On the other hand, the *knowledge building* approach maintains that collaboratively developed conceptual artefacts are the central epistemological means, contrasted to individualistically oriented learning (Bereiter, 2002). The *object of activity* is emphasized especially in activity theory as the starting point for understanding human activities (e.g. Engeström, 1987). The notion of 'object' is seen as increasingly important in other approaches as well (Engeström & Blacker, 2005 for various approaches related to objects).

Conceptually, elaborations of collaborative knowledge creation and the trialogical approach have been influenced by Knorr Cetina (2001) distinctions of *epistemic objects* and *epistemic practices*. According to Knorr Cetina, modern knowledge work cannot be described with the traditional notions of practices interpreted as recurrent routines or fixed commodities, but requires more dynamic notions of epistemic practices. Also other authors have combined 'artefact-oriented' or 'object-oriented' approaches to propose various forms of knowledge practices (Ewenstein & Whyte, 2009; Hakkarainen, 2009). The 'Practice turn' (Schatzki et al., 2001) in the social sciences and organizational learning carries implications for learning theories. Schön's (1983) notions of reflective practice as reflection-in-action and reflection-on-action are relevant when studying learning integrated with other activities. However, Schön's focus was on understanding human reflection during design activity contrasting the plan-based approach, in terms of how people modify their activity as they interact with the materials of a situation and in the dialogue with others. In this book, the authors address reflection in terms of collaborative processes, reflecting on practice transformation, and collaborative reflection aided by computer support.

'Knowledge Practices Environment' (KPE) is the technology platform investigated in many chapters of this book. KPE supports reflective and 'object-centred' knowledge creation practices. KPE provides virtual working spaces, called shared spaces, for the collaborative work. Working in a shared space enables viewing the knowledge artefacts and their relations from different perspectives and supports object-oriented development of all items. Basic tools and functionalities include, in addition to the common upload etc. functions, the following: note editor, commenting, context-based chat, semantic tagging, linking of items allowing also spatial organisation, and alternative process view for structuring the process, among others. Optional tools include Activity System Design Tool (ASDT), Visual Model Editor (VME), and mirroring tools (or analytic tools).

To understand the resources and processes involved when people transform their knowledge practices requires an integrative approach, since open-ended problem-solving processes cannot be completely planned in advance. This involves sensitive, flexible regulation, trying to tease out details of on-going activities and link them to the main goals and objectives, and openness to modifying plans and structures when a process asks for it. The *unit of analysis* in the knowledge creation in particular contexts require a multi-level methodology, which consists of interrelated levels of abstraction: micro, meso and macro, each of different temporal and spatial qualities. Micro-level data are data that represent actual, 'in-situ' interactions in knowledge-creation processes of what people actually do and contribute within the process. Meso-level data are data representing a series of interactions and productions as parts of evolving trajectories of participation in knowledge creation processes. Finally, macro-level data are data that record transformations, which involves broader historical and/or institutional perspectives. The three-tiered structure allows for in-depth analysis of moment-to-moment interaction to be combined with a perspective on evolving, object-oriented, open-ended inquiry.

Organization of the Book

The book seeks to integrate theoretical development, tool design and development, and empirical studies of the use and deployment of technological tools. Compared to other, contemporary European perspectives on technology-enhanced learning (e.g., Balacheff et al., 2009), the contributions in this book are framed within one, overarching theoretical perspective. Throughout the KP-Lab project, the trialogical approach to knowledge creation has been refined and operationalized through processes of technology design and empirical case studies of knowledge practices in higher education and professional practices. The first chapters in this book start by reflections on theoretical foundations and conceptual resources, followed by tools and design processes, and a selection of empirical studies on knowledge practices in higher education and professional practices including teacher training.

The Chapters

Paavola and colleagues (Chapter 1) introduce and explain the background for the trialogical approach to learning. It builds on classical approaches to mediation but aims at understanding novel practical and theoretical challenges of the knowledge society. The main theoretical development of the trialogical approach and different interpretations of the object-oriented knowledge work in the KP-Lab project are analysed in this contribution.

In Chapter 2, Batatia and colleagues consider tacit knowledge in knowledge creation activities. A variety of theories and models are surveyed in this chapter. This contribution attempts to elucidate relationships between trialogical learning and tacit knowledge for the purpose of theory-informed design of knowledge creation tools. Examples are given from three of the KP-Lab tools. The chapter points out implications for further development of tools.

The chapter by Doerr and colleagues (Chapter 3) introduces the KP-Lab Reference Ontology as an extensible conceptual model useful to analyse knowledge creation processes when different types of actors, things, and events come into play. The aim of the Reference Ontology is to serve as common ground for interoperability of the tools, and to support data analysis across cases. It is proposed to meet the needs of the heterogeneous KP-Lab ecosystem, re-presenting and interpreting data produced in multiple knowledge practices. Special attention is given to the dynamics that occur during knowledge creation processes and transformation practices.

Bauters and colleagues (Chapter 4) introduce the web-based application system Knowledge Practices Environment (KPE). KPE aims to support continual processes and development of products through collaborative interaction. It provides affordances for work with shared objects, e.g., artefacts, processes or practices, and a database for persistent storage of these objects. The main design ideas and features of KPE are elaborated, and results from a user study with KPE are presented.

In Chapter 5, Richter and colleagues present the Visual Modelling Editor (VME) for computer-supported modelling of conceptual artefacts. This tool allows users to create, compare and update different visual models, and to design and revise the underlying modelling language. VME has been introduced in several courses at two technical universities and the first user experiences showed that it can be used to create, reflect on and develop visual models as shared knowledge objects, and how modelling could be understood as an epistemic activity.

Toiviainen and colleagues (Chapter 6) explain in depth the co-design process leading to the Activity System Design Tool (ASDT). ASDT is integrated in the KPE, and specifically supports activities in distributed, highly specialized teams of expert workers. The authors argue that work processes of this kind are best understood as co-production of material objects while being organized in different teams. Collaborative work is analysed as inter-layered communication and design actions. Different perspectives shape the collective learning process materialized in creation and maturation of a shared, material object: the ASDT.

In Chapter 7, Richter and co-authors describe two mirroring tools for collaborative analysis and reflection (Visual Analyser and Time Line Based Analyser). These tools allow users to depict, explore, and interpret the digital traces of collaborative knowledge creation activities. The contribution shows how heterogeneous user groups (students, teachers, and knowledge workers) can interactively visualize tasks and activities over time. Mirroring tools can provide the users with tools and methods to enable reflection on their knowledge practices as they are engaged in project work over longer periods of time.

In their chapter, Lakkala and colleagues (Chapter 8) report on the use of specially developed design principles for trialogical learning in two higher education courses. They claim that efforts to operationalize the rather abstract design principles are useful because it helps to develop heuristic guidelines for educational practitioners and related tools. This requires that design principles are adapted to realities and challenges of each setting.

Karlgren (Chapter 9) introduces the trialogical approach to enrich medical simulation training in critical care. To portray the collaborative features, the cases' were modified based on trialogical design principles. Analysing the empirical material, typical recurrent patterns are discerned, and a development trajectory is suggested. The contribution contributes to contextualizing and extending the KP-Lab design principles by comparing the design patterns in the unfolding trajectory of solving educational problems.

Kosonen and colleagues (Chapter 10) explore activities of students in a multidisciplinary course in which business ideas and media technology solutions were developed for customers. The contribution discusses how a course based on the cross-fertilization between educational institutions and professional contexts was used in training new product-development professionals. The analysis of instructors' guidance and the subsequent changes made to students' working documents was conducted.

Damşa and Andriessen (Chapter 11) present an empirical foundation for the notion of shared epistemic agency. Within the knowledge creation perspective of learning the capacity for shared epistemic agency is enabled by groups' deliberate collaborative efforts to create shared knowledge objects. Epistemic and regulatory dimensions of the created knowledge object are elaborated and illustrated by actions during the collaborative creation of shared knowledge objects.

In Chapter 12, Kárpáti and Dorner apply knowledge building theory and the notion of epistemic agency to analyse teachers' satisfaction during transition to a new teaching practice in Hungary aimed at educating reflective practitioners, and employing a model referred to as mentored innovation. A large-scale study using an instrument to collect satisfaction and communication preferences is conducted. The authors report on the teachers' satisfaction, but also suggest an analysis to explore further strategies in teacher training that make knowledge creation processes more visible and accountable.

Sins and Andriessen (Chapter 13) report on a new kind of teacher-researcher collaboration at a secondary school where the goal was to collaboratively design a new learning module. The tensions among project team members became an object of analysis. The results are recommendations for a redesign of teaching practices, where the teachers themselves become targets for change. The authors propose a generic pattern of managing and resolving tensions for teachers as they reflect upon and constructively use tensions to transform practices. Aspects of activity theory are used in the conceptual framework for analysis and transformation.

Moen and Nes (Chapter 14) illustrate collaborative knowledge creation among professionals, where knowledge objects are (re)created based on interactions of persons and their material objects. The empirical example is a knowledge creation process where nurses' negotiate and consolidate versions of local and standardized procedures to co-create their knowledge object; a consolidated work description. This is discussed as a question-generating knowledge object, open to modification, change and evolution by the health care workers.

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1. THE TRIALOGICAL APPROACH AS A NEW FORM OF MEDIATION

INTRODUCTION

An emerging trend in theories about human learning and cognition is emphasizing collaboration, creative processes, and the use of new technology. Various changes in modern society form a basis for the change in learning theories, such as: 1) the rapid development of new technology which has formed and continues to form qualitatively new opportunities for distributed interaction and collaboration, 2) the pressure to create – and learn deliberately to create – new knowledge and transform existing practices in various areas of life, and 3) the complexity of modern society which means that people must combine their expertise to solve often unforeseen complex problems because individuals cannot solve problems alone. In order to underline this change and the emerging new phenomena related to collaborative creativity in theories of learning, the *knowledge creation metaphor* of learning has been proposed (Paavola, Lipponen, & Hakkarainen, 2002; 2004; Hakkarainen et al., 2004). This metaphor is a sequel to Anna Sfard's well-known distinction between *acquisition* and *participation* metaphors of learning (Sfard, 1998). The knowledge creation metaphor has a central basis on the theories emphasizing collaborative creativity, such as Nonaka & Takeuchi's theory of organizational knowledge creation (Nonaka & Takeuchi, 1995), and Bereiter's theory of knowledge building (Bereiter, 2002); as well as activity theory, especially Engeström's theory of expansive learning (Engeström 1987). The metaphor was developed and addressed first in the context of the computer-supported collaborative learning (CSCL) and is, accordingly, recognized mostly in the CSCL literature (e.g., Stahl, Koschmann & Suthers, 2006; van Aalst 2009) but also in relation to novel technologies more generally (e.g., McLoughlin & Lee, 2008), and when learning approaches have been reviewed (e.g., Tynjälä & Häkkinen, 2005).

The knowledge-creation metaphor of learning functioned as a foundation for the KP-Lab project (Knowledge Practices Laboratory), a five-year project (February 2006 – January 2011) representing various approaches to research and development of educational technology. A goal of the project was to develop theories, technology-enhanced tools, practical models, and research methods that elicit deliberate advancement and creation of knowledge as well as transformation of knowledge practices in higher education and in the workplaces. The partners in the project, who represented educational research, technology development, and various theoretical outlooks, focused on models and tools for higher education,

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teacher training, and the workplace. The knowledge-creation metaphor of learning appeared to provide an apt theoretical background for this kind of project when it included partners with somewhat different theoretical starting points. Instead of starting from some specific theoretical outlook concerning learning or educational technology, it functioned more like an "umbrella" framework emphasizing commonalities between different forms of expertise and theoretical approaches which all seek to understand phenomena central to the project's aims and research. As a co-design and integrated project, KP-Lab itself represented a knowledge-creation process in which objects are hard to specify or predict in advance because they shift and may emerge only towards the end of the process. Nowotny et al. (2001, 145) take the view that the process (in "Mode-2 objects") is more one of groping towards an "object of negotiation", which has yet to assume its scientific or technological "gestalt", than of knowing from the beginning what its contours and content are likely to be.

To embody the knowledge creation metaphor in practice in relation to technology-enhanced learning and through a particular research approach, a *trialogical approach* was elaborated. One of the original aims of the KP-Lab project has been to apply the trialogical approach to learning by developing pedagogical practices, models and tools to support learning activity based on collaborative knowledge creation. In this paper, we elaborate how the trialogical approach has been determined. First we delineate the main starting points of the approach, taking influences from other approaches to mediated activities. We then elaborate how the trialogical approach has been developed in the KP-Lab project by framing tools and knowledge practices investigated there. Finally, we look briefly at the challenges of developing object-oriented knowledge practices further.

DEVELOPING FORMS OF MEDIATION

The trialogical approach builds on classic approaches emphasizing *mediation* as a basis for understanding human activities. Humans can control their behaviour from the outside, that is, culturally and socially, using signs and tools (Vygotsky, 1978). Signs, tools, and artefacts bring in "thirdnesses", that is, mediated processes which are interpreted and developed in iterative, social processes (Peirce, CP 1.363; CP 5.138). To serve the knowledge creation metaphor, the focus on various forms of mediation has been used to overcome such dichotomies as the structural/ processual, and individual/collective in studying human activities. In addition, mediation opens up new potentialities in technologically supported activities. Modern knowledge work supported by digital technology both requires new means for working with epistemic objects and knowledge artefacts and highlights their role for understanding learning differently. The trialogical approach emphasizes (knowledge) artefacts as things which mediate activities but are also taken themselves as objects to be created and developed by the actors. We argue that this triple nature (tool/concrete object/object to be developed) of situated artefacts forms the essence of novel knowledge practices, and puts the emphasis on how to organise actual processes of learning and working where mediating artefacts are partly pre-existent, partly created, and partly modified in the activity whose constituents they ultimately are.

There are also other approaches which underline the new role and search for redefinition of epistemic objects and their artefacts. Karin Knorr Cetina (2001) has emphasized that the emergent phenomena of the modern knowledge society challenge traditional ways of understanding the meaning and nature of practices and objects as a part of human activities. Practices are often seen as recurrent processes and rule-based routines, but modern "epistemic practices" redefine this notion. Knowledge-centered work requires a more dynamic, creative, and reflective notion of practice. Knorr Cetina has also emphasised that the notions of object and especially epistemic object take on a new meaning in this situation. 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". Epistemic objects "appear to have the capacity to unfold indefinitely" (Knorr Cetina 2001, 181). The trialogical approach comes close to these ideas of epistemic practices and epistemic objects, especially when combined with the use and development of collaborative technology (the latter has not been the focus of Knorr Cetina's concept of "epistemic objects"). The aim has been to develop technology to support work with "epistemic objects" and to organize this kind of work.

Within the KP-Lab project, various tools were developed intended to support collaboration on shared objects, and transforming and reflecting on knowledge practices, something which goes beyond "information genre" and "communication genre" (cf. Enyedy & Hoadley, 2006). A basic platform, the 'Knowledge Practices Environment', (KPE) was especially developed for supporting "object-centered" knowledge practices (planning, versioning, commenting, annotating, etc.) (more detail on KPE: Bauters et al., this volume; Lakkala et al., 2009; Markkanen et al., 2008). For developing the trialogical approach, important intermediate abstractions were the *types of mediation* (Rabardel & Bourmaud, 2003; see also Beguin & Rabardel, 2000) which emphasized new forms of mediated activity provided by technology. The KP-Lab project developed an interpretation of these types (Hakkarainen, 2008) in order to use them as guidelines for technology requirements. The result was a list of four main types of mediation that the technology was aimed at supporting:

- *epistemic mediation* is related to creating, organizing, linking and working with knowledge artefacts,
- *pragmatic mediation* is related to organizing, planning and coordinating knowledge-creation processes, and means for updating and revising the plans and coordinating them with other activities,
- *social* (or *collaborative*) *mediation* concerns building and managing networked communities and the social relations required for carrying out knowledge-advancement efforts, as well as cross-fertilization across different groups and communities, and
- *reflective mediation* is understood in terms of making knowledge practices visible, reflecting on, and transforming them.

The basic notion in the KP-Lab project was to support creating, drafting, versioning and organizing the work with knowledge artefacts, as well as support negotiation, commenting and reflecting on them. The aim was to enable participants to reflect on their ways of working and performing tasks, and take their own knowledge practices and processes as shared objects to be analysed and developed collaboratively. The KP-Lab technology was designed then to support *multimediation* (cf. Bodker & Andersen, 2005) by providing a shared knowledge space that facilitates all four types of mediation mentioned above and the flexible use of them together. There are, for example, technology-enhanced views in KPE which are in line with the types, that is, the Content View (cf. epistemic mediation), the Process View (as well as an Alternative Process View, cf. pragmatic mediation), and the Community View (cf. social mediation) (for more detail see Bauters et al., this volume). There are also special analytic tools developed to support reflective mediation (Richter et al., this volume). Technology then provided new applied ways of interpreting what it means that the activity is organized around shared objects in knowledge-intensive work. Nevertheless, the main understanding of multimediation required *integrated tools* for constructing epistemic, pragmatic, social, and reflective *activities* in any context of professional practices.

The trialogical approach comes close to many existing approaches to collaborative learning focusing on open-ended problem solving, like *knowledge building*, *inquiry learning*, *project-based learning*, *the situated-interaction approach*, or *problem-based learning*. In each of these learning approaches, there are many varieties and interpretations. The most distinctive feature of the trialogical approach is, however, that it emphasizes open-ended and challenging work on shared objects meant for subsequent use from a variety of perspectives. The trialogical approach combines features from approaches highlighting conceptual aspects of inquiry processes and idea-centered work (like knowledge building or inquiry learning) with features highlighted in pragmatically oriented approaches (like project-based learning). In modern knowledge work, epistemic issues are embedded in practical concerns, and are not alternatives. The trialogical approach aims to promote the work with knowledge artefacts by examining what these artefacts are, how they are created and modified for specific uses and how these processes are supported in practice. The outcome is constructed not only by the ideas that they inhere or by versions that are produced but how the artifacts are used and developed for maintaining new knowledge practices, which are both elements of and contextualized by a more long-standing object-oriented activity.

THE TRIALOGICAL APPROACH DEVELOPED WITHIN THE KP-LAB PROJECT

The technology developed in the KP-Lab project was originally defined as a virtual shared space with a set of tools enabling collaborative knowledge creation practices. According to the vision formulated early on in the project, the KP-lab project:

> *… aim[s] at understanding how people collaboratively, in long-term processes, develop* novel epistemic things and transform their knowledge practices, and how students in higher education do the same by cross-fertilizing professional and educational practices and solve complex, authentic problems with the help of innovative knowledge practices and educational technology. The modern information and communication technology not only facilitates knowledge creation around shared objects but also puts forward the need to develop this kind of an approach about trialogical learning. (KP-Lab, 2007).

The focus was on collaborative processes for developing "epistemic things" and on transforming knowledge practices with the help of technology developed in the project. A specific focus was on higher education courses in which there is a close link to professional practice. Workplace research cases were also investigated where collaboration on "virtually constructed objects" was at the heart of new learning challenges.

DESIGN PRINCIPLES AS A FRAMEWORK FOR EMERGING KNOWLEDGE PRACTICES

Early on (in the first year of the project), new knowledge practices were defined by means of a set of *design principles* elaborated for complex learning settings (Bell et al., 2004; Kali, 2006). The trialogical design principles were meant to serve several purposes in the project, especially to function as a middle ground between theoretical ideas and practical aims, and to give broad guidelines and principles for the technology development and pedagogical emphases. There was a clear need to identify such basic characteristics of the trialogical approach in a project where there were several educational and technological partners involved with a variety of backgrounds with a new pedagogical emphasis. These design principles were *not* meant as a fixed set of normative rules but as providing outlines for evolving knowledge practices, supposed to be investigated and revised during the project.

The design principles had a background in analyses, done by the participants of the project, of theories representing the knowledge creation metaphor of learning. We had previously (before the KP-Lab project) analysed similarities in otherwise quite different theories representing the knowledge creation metaphor, and ended up with the following common characteristics (Paavola et al., 2004, 562) that may feed ICT-mediated knowledge creation and its tools and practices:

1. The pursuit of newness
2. Mediating elements to avoid Cartesian dualisms
3. Viewing knowledge creation as a social process
4. Emphasis on the role of individual subjects in knowledge creation
5. Going beyond propositional and conceptual knowledge
6. Recognizing conceptualizations and conceptual artefacts as important
7. Interaction around and through shared objects

The characteristics of the trialogical learning were discussed at the kick-off meeting of the KP-Lab project. The scientific coordinator of the project also drafted a paper listing first 12 and then 31 characteristics of trialogical learning and technology design (Hakkarainen, 2006). These characteristics were explicitly linked to knowledge building principles by Scardamalia (2002), but were also influenced by the activity theoretical research. Additional sources for defining the design principles were previous experiences of the KP-Lab partners in developing learning technology, and an explicit goal of the project was to develop courses in which students would be in close contact with real customers solving complex problems and developing specific end products for those customers.

The design principles of the trialogical approach were then formulated by the project partners on the basis of these various sources. The aim was to make a relatively short list of design principles which would cover the basic characteristics of the approach. At the end of the project, the trialogical design principles (DPs) were formulated as follows:

DP1 - Organising Activities Around Shared Objects.

The first DP explicates the central idea of the trialogical approach, emphasising practices through which participants organise their collaboration for developing shared "objects". These shared objects are both various kinds of knowledge artefacts (documents, plans, models, prototypes, design artefacts, etc.) but also practices and processes (i.e., ways of working or organising the collaboration) that are developed together. One vital feature of the trialogical approach is that the work and versioning of external knowledge artefacts (made for some later use) are seen to structure human interaction essentially. These shared objects, and versioned knowledge artefacts provide a concrete common ground and mediating element. At the same time, participants are encouraged and supported in developing and reflecting their processes of organising their collaboration.

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

One point of the knowledge creation metaphor is that in order to understand and support knowledge creation processes properly the dichotomy between individualistic approaches to learning (often associated with the acquisition metaphor of learning) and purely social interaction (here associated with the participation metaphor of learning) must be transcended. This means that when people are involved in creative processes, the role of individual expertise is merged with fertile social and cultural processes (and vice versa). Participants are encouraged to take the agency of their own work, collaborative processes, and those objects that they are developing.

DP3 - Fostering Long-term Processes of Knowledge Advancement with Shared Objects (Artefacts and Practices).

Processes of developing something new together or developing knowledge practices usually takes a lot of time (from individuals, groups and social institutions). The focus is on practices and tools that support work with a longer time frame than is usually done in educational settings (within one course). This includes various aspects like doing things that are meant for some subsequent use, encouraging links between different courses, creative re-use of previous practices and knowledge artefacts, and providing enough time for the iterative cycles needed in knowledge creation processes.

DP4 - Emphasising Development and Creativity on Shared Objects Through Transformations and Reflection.

Theories and models belonging to the knowledge creation metaphor of learning emphasise 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.

DP5 - Promoting Cross-fertilization of Various Knowledge Practices and Artefacts Across Communities and Institutions.

One focus of the KP-Lab project courses was on learning settings in which students solve complex, “authentic” problems (meaning problems that have a relevance outside the educational setting in question) and were also producing objects for purposes outside educational institutions. This kind of “cross-fertilization” between different institutions and practices is an important motivation for students and teaches the competence needed in modern knowledge work.

DP6 - Providing Flexible Tools for Developing Artefacts and Practices.

Beside the first DP, this one is central to the trialogical approach. Trialogical processes can be undertaken without any special technology; people have developed knowledge artefacts and practices collaboratively for specific purposes without digital technology, but new digital technology provides clearly new means and affordances for these processes (for collaboration, sharing, reuse, reflection, modification, etc.). In the KP-Lab project, KPE was developed to support working with shared objects and artefacts by taking different forms of mediation defined in the project (epistemic, pragmatic, social, and reflective) into account.

As can be seen, these formulations of design principles are quite general and provide a perspective on knowledge practices central to trialogical processes (i.e., for collaborative work with shared objects meant for subsequent use). The basic idea is that collaboratively developed shared objects are put in the centre, and mediate the participants' activities in several dimensions (see Figure 1.1).

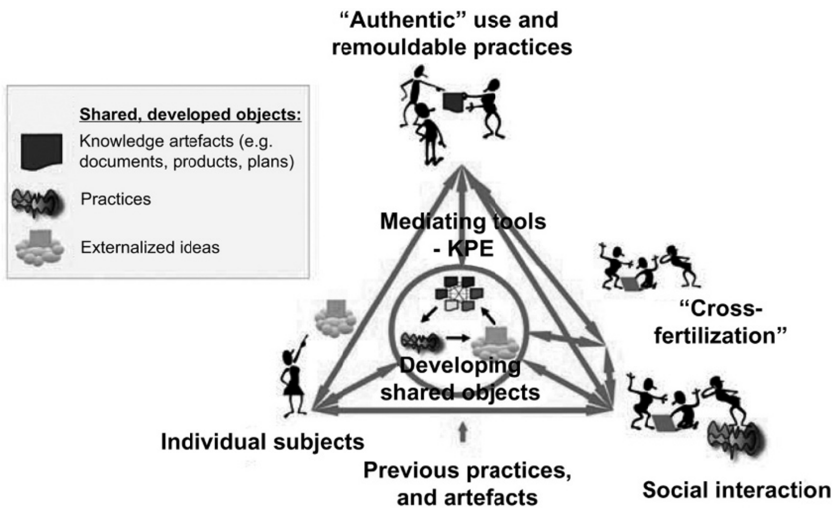

Figure 1.1. A figure on the trialogical approach depicting various dimensions of mediation with a focus on shared objects.

The design principles themselves served different, overlapping purposes in the KP-Lab project (Paavola et al., 2011). They: 1) helped to explicate central characteristics and features of the theoretical approach which was also new for the developers (that is, to give outlines for an approach to be developed during the project), 2) helped to select, focus, and report research cases investigated in the project, 3) afford suggestions for practitioners for developing existing knowledge practices in line with the approach, 4) provided guidelines for technology development.

The meaning and interpretation of the design principles, used and revisited several times during the project, was specified in relation to the KP-lab project. Not all knowledge practices were emphasised as much during the project. The original aim, for example, was to investigate and promote longer-term changes in knowledge practices within some specific contexts, but this was not implemented to a large extent because of the revisions suggested by the project reviews of the cases investigated. From the point of view of research, it was also a challenge to investigate transformations *across* courses when higher education is organised mainly around quite separate courses. Similarly, there were plans to support the interaction between personal and collaborative working areas (see DP2) with the help of the specific functions of the tools, but the functions were not actualized to the extent planned. Not all plans could be implemented fully in one project and choices needed to be made. What was somewhat surprising was that the design principles themselves did not change much from their outer form during the project (Paavola et al., 2011). They were re-evaluated and revised several times during the project (on the basis of research cases). Beside various specifications, there were not any major changes in them.

The design principles also provided guidelines for selecting research cases in the project and reporting results from them, although their use was not unproblematic. Especially at the start of the project, there was a tendency to interpret these design principles so loosely that almost any kind of knowledge practice, or technology supported projects could be included. This was problematic when the aim was to find courses with trialogical elements which could be further supported by novel tools designed in the KP-Lab project. Specifications were needed for formulations of the design principles accompanied by discussions on trialogicality itself.

The design principles were also used as practical guidelines and hints for developing and analysing courses (Lakkala et al., this volume; Karlgren, this volume). The trialogical design principles are very challenging if they are all implemented in a strong sense. Often in courses in higher education there are just not enough resources or time for taking all the aspects into account, which is why they were used as “vehicles of innovation”, that is, providing ideas and directions which can be implemented or used in various forms and with differing strength in specific cases. The design principles were then used as tools for intervention, although this interventionist way of using them was not as prominent as was the framework for observing knowledge practices emphasised in research cases.

The influence of DPs on technology development turned out to be more indirect than was originally planned. Early on in the project it became clear that DPs were accounted by technology design as too abstract for directing the actual co-design of the tools alone. They provided, however, a general theoretical and pedagogical outline which was checked from time to time in the project in relation to the means of collecting requirements for the technological development. The types of mediation (see above) provided a basic framework for technology development (Bauters et al., this volume). Technology was developed to support work with shared objects from these different mediation perspectives.

As a summary of research with and on the design principles, we can delineate at least three perspectives for further design of technology-enhanced learning:

1. Multimediation as a source of learning, in terms of deliberately creating, sharing, and advancing knowledge, implies a complex combination of qualitatively different processes, such as creating artefacts related to epistemic objects and working with them, organizing interaction, linking and coordinating knowledge-creation processes, managing and reflecting ongoing processes, etc. The practices themselves have a complicated architecture in which they are becoming more flexible and contextualized entities. They themselves start to resemble an activity where “symbolic activity penetrates the process of tool

use" (Vygostky, 1978, 24). This penetration creates entirely new opportunities enabled by digital technology.

2. Novel knowledge practices can be identified with iterative processes in which the artefacts are produced for promoting and mediating object-oriented activities. As we have argued, the triple nature (tool/concrete object/object to be developed) of situated artefacts forms the essence of novel knowledge practices, and puts the emphasis on how to organise actual processes in which mediating artefacts are partly pre-existing, partly created, and partly modified in the activity whose constituents they ultimately are. The participants do not necessarily share the same meanings with regard to the ongoing activities, but they share the process of engagement and subjectively unique understandings on their participation (Engeström, 2009).
3. In creating technology-enhanced knowledge practices, co-design processes are uneasy, partly because the different disciplinary approaches and terminologies. On the other hand, "crossing boundaries involves encountering difference, entering onto territory in which we are unfamiliar and, to some significant extent therefore, unqualified" (Suchman, 1994, 25). To overcome such a deficiency, boundary crossing calls for a process-oriented theory of organising, such as a "dialogical mediated inquiry" (Lorino, Tricard & Clot, 2011) or trialogical learning which is collaborative and accommodated to the beginning and ending of co-design circumstances.

FUTURE CHALLENGES OF THE TRIALOGICAL APPROACH

One of the basic ideas of trialogical learning is that modern knowledge work should be seen more through unfolding and dynamic objects, or knowledge artefacts. In the trialogical approach, this "objectualization" builds on an epistemology where subjective, intersubjective, and objectual aspects are inseparably linked, not a stark opposite to individualistic or interactionist approaches to learning (cf. Davidson, 2001). In the KP-Lab project the focus on shared objects was a crucial challenge and a driving force theoretically. This challenge produced many discussions on the nature of "shared objects". This reflects somewhat different theoretical outlooks which formed the background of the project. "Object" is a central theoretical concept in activity theory whereas in knowledge building the work on conceptual artefacts is emphasized. There are influences on both of these in the "shared objects" of the trialogical approach. On the other hand, this also reflects the complicated nature of knowledge work which includes working with various kinds of objects and artefacts, and there are different, partially overlapping conceptualizations aiming at understanding related knowledge processes and practices (e.g., Schmidt & Wagner, 2002; Ewenstein & Whyte, 2009).

In reviewing cases conducted in the KP-Lab project we can find three ways in which shared objects were constructed:

1. One emphasis was on collaborative and systematic work with knowledge artefacts, and how to organise the activities of participants for versioning and

working iteratively on them. Alternatively, the focus could be on knowledge practices if the aim was to develop them concretely. This kind of iterative work on actual knowledge artefacts and their role in guiding the interaction was important, especially in theoretically oriented papers on trialogical learning. It has been emphasised that this kind of approach is an alternative to the "meaning-making" tradition often espoused in computer-supported collaborative learning (Paavola & Hakkarainen 2009). KP-Lab tools provided some support for this kind of versioning with knowledge artefacts. Additionally, not all tools were provided by the project but were loosely integrated into the environment (like the Google Docs, or a wiki). The KP-Lab courses showed that students are not used to working like this (versioning shared artefacts with many iterations) and short-term courses do not provide much time for learning these kinds of knowledge practices. Clearly such activities need more sustained practice.

2. In many pedagogical cases investigated in the project, a broader approach to "shared objects" was emphasised, however. These were mainly relatively short term projects (usually one semester) where the aim was to develop different kinds of project outcomes. The focus was then on organising the collaborative efforts around shared topics or project assignments. From the students' point of view, the "shared object" might remain as a more abstract aim or phenomenon with which the group in question was working than just the knowledge artefacts which they were using. On the other hand, various kinds of activities and knowledge creation processes helped participants to work with these shared objects. KPE was supposed to provide a means of organising these knowledge creation processes (strengths and challenges of KPE are summarised in Bauters et al., this volume).
3. A third construction of shared object emphasised "object-bound" activities with an interplay of dialogical (with meaning-making, communication, and exchange of ideas) and trialogical (iteration of knowledge artefacts) activities. Different varieties of these object-bound activities were found, that is, activities in which commenting, chatting, or discussions referred to some specific artefacts or parts of artefacts instead of more general discussions. Varieties of object-bound activities were found to be especially important in workplace cases. KPE was used so that during face-to-face meetings (or sometimes in video meetings) the shared working area of KPE (a particular "shared space") was projected onto the screen, and knowledge artefacts produced and modified as well as tasks and plans were discussed collaboratively. The aim was often to modify the knowledge artefacts, but the activity concentrated on discussions, and modifications were done later on by some of the participants.

These three constructions of shared objects are clearly overlapping in nature but with a different emphasis. The first one ("trialogues") emphasises collaborative drafting and versioning of knowledge artefacts (or practices), the second one (broader knowledge creation processes) emphasises focused and targeted project work on common phenomena, and the third one (a variety of object-bound activities) emphasises the combinations of working with knowledge artefacts and dialogical activities.

In the trialogical approach, objects alone are not so important, but rather form the driving force of the collaborative knowledge work as a part of those processes in which they are developed (Knorr Cetina 1997, 2001). However, as we have pointed out, knowledge creation processes with new technology challenge the notions of 'object' and 'tool' in a fundamental way. Knowledge-laden objects are worked on in the situated processes and produced as artefacts in order to use them iteratively as tools in the further ongoing processes. These intermediate processes provide knowledge practices with an epistemic frame of activity rather than narrow skills, competences, or contents (Brockmeier & Olson, 2009). The trialogical approach has shown its relevance for investigating these intermediate processes and their integrated, technology-enhanced tools. Pedagogically, the set of design principles (DPs) delineated knowledge practices employed in the project. DPs provided a horizon of potential ways of developing the trialogical processes further, and KP-Lab focused on certain aspects of them. One obvious challenge is to find ways of supporting and investigating longer-term changes in knowledge practices by individuals, groups and institutions embedded in practical concerns.

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2. TACIT KNOWLEDGE AND TRIALOGICAL LEARNING: TOWARDS A CONCEPTUAL FRAMEWORK FOR DESIGNING INNOVATIVE TOOLS

INTRODUCTION

The concept of tacit knowledge has received a great deal of attention recently. From a knowledge creation point of view, much of the related discussion fails to provide any deep insights. Notwithstanding the superficial treatments commonly encountered, the concept embodies crucial aspects of learning that are critical for the success of KP-Lab. Indeed it became one of the core concepts of the project; capturing tacit knowledge within processes of learning and knowledge creation in higher education and workplaces has been one of the basic ideas which we identify according to three theoretical perspectives: The knowledge-creating company (Nonaka & Takeuchi, 1995), the cultural historical activity theory (Engeström, 1999a), and the knowledge-building communities (Bereiter, 2002).

Yu Zhenhua considered the different interpretations of tacit knowledge (TK) in his article (Zhenhua 2004). He took the work of Michael Polanyi as a starting point. He introduced the term "tacit knowing" or "tacit knowledge" into philosophy in his magnum opus *"Personal Knowledge"* (Polanyi, 1958). Since then, different philosophical traditions – e.g., phenomenological, hermeneutical, Wittgensteinian and Polanyian traditions – have pursued work on this notion and related interpretations, contributing to new research as the large body of secondary literature demonstrates. It is no exaggeration to talk about an ongoing discourse on tacit knowledge. The notion of "tacit knowledge" or "tacit knowing" is rich in its philosophical interpretations, with many theoretical dimensions.

Tacit knowledge means the range of *conceptual and sensory information* and *images* that can be brought to the fore in an attempt to make sense of something. It is based on the idea that such knowledge is not something expressed in symbolic or declarative means but by signs and structures embedded in visual representations, practices, concrete artefacts, diagrams. This is something different to propositional knowledge. The key to knowledge creation models is to understand how these "weaker" forms of knowledge are used and made explicit in a meaningful way in collaborative processes.

Michael Polanyi developed his version of the concept during the 1950s to emphasize that although knowledge is social, explicit and public (which is the

A. Moen, A. I. Mørch, S. Paavola (Eds.), Collaborative Knowledge Creation: Practices, Tools, Concepts, 15–30.

traditional understanding of knowledge as a noun) it also has a strong "tacit dimension" (e.g. Polanyi 1958; 1966). Things like personal experiences, taste, and involvement are central aspects of human knowledge, especially when something new is created. According to Polanyi's famous dictum "we can know more than we can tell" (Polanyi 1966, p. 4) which means that discovery is not followed by articulated rules or algorithms, but is aided by tacit elements of which we are not aware. Tacit knowledge is *not* supposed to be something that could not in principle be made "focal" or explicit, but the idea is that tacit knowledge is an atomic element of all processes of knowing.

To Polanyi, knowledge is formulated/formal or unformulated/informal. The first kind of knowledge is called explicit or articulated knowledge, whereas the second is called unarticulated or tacit knowledge. To Polanyi, articulation means verbal articulation even if he proposes a wide understanding of language, which includes various symbolic forms like mathematical formulae, maps, and diagrams. The *first meaning of Polanyi*'s concept of TK is that human beings have certain cognitive powers, which in principle cannot be exhausted by linguistic means alone. Polanyi claims that TK is the foundation of all explicit knowledge and concludes: "While tacit knowledge can be possessed by itself, explicit knowledge must rely on being tacitly understood and applied. The *second meaning of Polanyi*'s concept of TK is that tacit knowledge is an activity that is better described as knowing, i.e. the process or pre-logical phase of knowledge.

Tacit Knowledge and Collaborative Knowledge-Creation Processes

One central basis for the KP-Lab project has been the *knowledge-creation metaphor of learning*, that is, such models and theories of learning and knowledge advancement that emphasize dynamic and collaborative processes of transforming prevailing knowledge artifacts and practices (Paavola, et al., 2004; Hakkarainen, et al., 2004). Central representatives of this approach are Nonaka & Takeuchi's (1995) model of organizational knowledge creation, Engeström's (1999a) model of expansive learning, and Bereiter's (2002) model of knowledge building. *Tacit knowledge* can be seen as an important aspect of each of these three models although its interpretation varies. Furthermore, it should be noted that both Engeström and Bereiter are quite critical towards the concept itself, and are prone to use related models and concepts.

In their book, *The Knowledge-Creating Company*, Ikujiro Nonaka and Hirotaka Takeuchi (1995) presented a model of innovation processes, central to which is an epistemological distinction between two sorts of knowledge, *tacit* and *explicit*[1]. Explicit knowledge is knowledge that is easy to articulate and express formally and in clear terms. Tacit knowledge, which is more important in creating innovations, is "personal knowledge embedded in individual experience and involves intangible factors such as personal belief, perspective, and the value system" (viii). Another starting point in their model is an "ontological" distinction between different levels of "entities" that operate in knowledge creation; the individual, group, organizational, and inter-organizational levels. According to Nonaka and Takeuchi, knowledge is created and transformed spirally from the individual level to the organizational level, and finally between organizations. The dynamics of this model arise from the interaction between tacit knowledge and explicit knowledge. The knowledge creation spiral starts from *socialization*, sharing tacit knowledge and experiences at the group level. The next phase, *externalization*, is central in knowledge creation. In this phase, tacit knowledge is made explicit and conceptualized using metaphors, analogies, and concepts. In Nonaka and Takeuchi's model, the basic source of innovation is tacit knowledge, which needs to be explicated in order to be transformed into knowledge that is useful at the levels of the group and of the whole organization. *Combination* holds that already existing explicit knowledge is combined and exchanged. Finally, in order to have real effects in organization, the explicit knowledge of the group or organization must be *internalized* by individuals and transformed into tacit knowledge and into action through "learning by doing". After internalization, a new round of the knowledge spiral will start again.

Yrjö Engeström (1999b) studied and developed innovative learning cycles in work teams using *Cultural-Historical Activity Theory* (CHAT). Engeström's model of expansive learning in work teams is based on a learning cycle with seven stages in its ideal form (Engeström 1999b, p. 383–384; cf. Engeström, 1987, p. 188–191, p. 321–336). The cycle starts with individual subjects questioning and criticizing some existing practices. This is followed by an analysis of the historical causes and empirical inner relations of the activity system in question. After that, participants engage in modelling a new solution to the problematic situation. Then, they examine the new model by experimenting and seeing whether it works and what potentialities and limitations it has. Next, the new model is implemented in order to explore practical actions and applications, and the process is evaluated during an activity of reflection. Finally, participants engage in consolidating this practice in its new form. Through this expansive cycle, in which the actors focus on reconceptualizing their own activity system in relation to their shared objects of activity, both the objects and the existing scripts are reconceptualized; the activity system transformed and new motives and objects for the activity system created. The model should be understood as an ideal or heuristic tool for analyzing elements of expansive learning, as the cycles of expansive learning do not necessarily follow any fixed order. The same cycle can be seen as a background for the change laboratory method (Engeström, Engeström, & Kärkkäinen 1995; Ahonen, Engeström, & Virkkunen 2000). Tacit knowledge is not explicitly emphasized in expansive learning, and more stress is placed on knowledge embedded in practices. Engeström has, however, given credit to Nonaka and Takeuchi's circle for identifying various modes of knowledge, and discussing transitions between tacit knowledge and explicit knowledge (Engeström, 1999, p. 401). Engeström has also criticized Nonaka and Takeuchi for not taking into account the first two phases of the expansive cycle -- questioning and analyzing the situation -- and in doing so, neglecting the importance of controversies and conflicts in knowledge creation (Engeström, 1999b, p. 380).

Carl Bereiter (2002) argued that the emergence of a knowledge society has given rise to dealing with knowledge as a thing that can systematically be produced and shared between members of a community. Scardamalia and Bereiter (1994) have proposed the concept of *knowledge building*, which refers to collective work for the advancement and elaboration of *conceptual artefacts*, the entities of the world of man-made, non-physical things (product plans, business strategies, marketing plans, theories, ideas, models, etc.). An important aspect of Bereiter's theory is to make a conceptual distinction between learning, which operates in the realm of mental states (in Karl Popper's World 2), and knowledge building, which is generated by human minds whilst operating in a socially shared realm (Popper's World 3), which again makes use of material (World 1) objects for realization (e.g. paper, computer screens, ink). According to Bereiter, Nonaka and Takeuchi's model of tacit knowledge (and explicit knowledge) is still rooted in a mentalistic "folk epistemology": It is based on the externalization of tacit knowledge and appears to rely on a mentalistic assumption that knowledge resides and is created in an individual's head. Bereiter feels that what is missing from this model is knowledge "in the world" considered as "conceptual artefacts," and the idea of knowledge building. Tacit knowledge as such is, however, important in Bereiter's model of expertise. Skills and know-how manifest themselves in performance, but tacit knowledge is much harder to recognize directly. Bereiter and Scardamalia 1993, p. 133–152; see also Bereiter, 2002) argue, for example, that knowledge of "promisingness," which is for them one form of tacit knowledge, is an essential resource of creative experts. Having continuously solved problems in their own area of expertise, creative experts have some sort of sense about what is promising, and how to make progress in their field. They deal with uncertainty, and make ventures and risky efforts part of their innovative processes.

On the basis of the above three models concerning collaborative knowledge creation, it can be said that an important aspect of the knowledge creation metaphor of learning concerns mechanisms where non-explicit knowledge is conceptualized in collaborative processes. Different theories emphasize different kinds of non-explicit knowledge, often by using other concepts than "tacit knowledge", or interpreting it slightly differently. Nonaka & Takeuchi emphasize *personal hunches* and *insights* that are rendered explicit for the use of the community, Engeström emphasizes *practices* and *activities*, which are reflected and transformed into collective processes, and Bereiter *conceptual artefacts* and *ideas* that are collaboratively developed. All of them come close to that aspect of Polanyi's original idea that knowledge creation and discovery is not rule-governed or an algorithmic process based solely on explicit knowledge but involves non-explicit and iterative processes. In relation to Polanyi's original ideas, they all seem to emphasize more communal and collaborative elements in making tacit knowledge more explicit than Polanyi did. In addition, Nonaka & Takeuchi's model is the most individualistically centred.

TECHNOLOGIES FOR TACIT KNOWLEDGE

Technologically speaking, two disciplines have addressed knowledge processing: artificial intelligence (AI) and information systems. In their quest to capture, store, and make use of knowledge, both approaches have faced difficulties related to the specific nature of tacit knowledge (Harlow & Inam, 2006; Holthouse, 1998). Two contradictory directions evolved from AI research. The “mainstream” AI researchers developed expert and knowledge based systems as attempts to solve the problem. They have been criticized for ineffectiveness due to their systematic attempts to articulate all forms of knowledge into rules, procedures, frames, schemata, etc. The rigid aspect of these systems fails to fulfil the aim of knowledge-based systems (modelling the application of human knowledge). Despite related philosophical debates, limitations to knowledge codification have been misunderstood or ignored in the AI community (Grant & Oureshi, 2006; Luo et al., 2006). The other discipline is design research. Donald Schön became one of the main proponents. His critique of Simon’s notion of design as modelled by rule-based production systems drew on Polanyi (1966) and Wittgenstein. Schön (1992) suggested that computer support for tacit knowing in design should be about design assistance rather than design automation, and provided by computer based design environments rather than expert systems. Following on from this, Fischer (1999) developed prototypes of domain-oriented design environments to operationalize Schön’s notion of reflection-in-action (Schön, 1992). Knowledge management systems have been the approach adopted by Information systems to tackle the issue. Mainly based on Nonaka’s model, knowledge management systems proposed tools and techniques for socialisation, externalisation, combination, and internalisation.

Forsythe (1993), drawing on ethnographic material, explored epistemological perspectives of knowledge engineering, and showed that neglecting the complexity of social interactions leads to incomplete or irrelevant technology. She states that knowledge is social in nature and suggests that it can still be represented correctly by composing the set of agents’ knowledge representations. To Grant and Qureshi (2006), the failure of knowledge management systems is due to the attempt to represent and store tacit knowledge, overlooking the limitations of knowledge codification. The authors claim that implementation approaches must take into account the personal nature of knowledge and the importance of groups and communities. Along this line, emphasis has been placed more on practice-based theories of knowing and learning (Blackler et al., 2000), and the importance of taking into account context when designing and implementing knowledge management initiatives (Thompson & Walsham, 2004), including those involving information and communication technologies (Walsham, 2001). Tacit knowledge is revealed through personal interaction. Information and communication technologies can be used to foster interaction and provide a lateral medium enabling non-intrusive measure of tacit knowledge (Ritchie et al., 1999). The underlying principle is that although tacit knowledge cannot be codified, it is nevertheless a measurable phenomenon that enables the development of relationships and study effects (Harlow & Imam, 2006).

Abidi et al. (2005) presented a knowledge management methodology and its computational implementation. The described system allows the acquisition and representation of tacit knowledge in the form of clinical scenarios. The acquired knowledge is used in health-care decision-support and medical education systems. Other studies have focused on knowledge management and learning in intensively knowledge-driven activities (French et al., 2007; Frade, 2004; Mansell & Curry, 2002; Masuzawa, 2001). Hagengruber & Riss (2005) argue that there exists no universal static knowledge valid for all contexts. Knowledge is described by means of relations between entities within specific contexts. The authors suggest that tacit knowledge can be expressed as shifts in context. Similarly, Cheah et al., (2003) use scenarios for the description of a healthcare situation. Instead of static knowledge representation, a collection of knowledge for different situations is preferred.

CONCEPTUAL FRAMEWORK

The role of tacit knowledge in trialogical learning is examined according to three KP-Lab background metaphors of learning, i.e., knowledge acquisition, participation, and knowledge-creation metaphors.

> *The knowledge acquisition perspective* addresses individual knowledge structures and processes essential in learning to become expert. Tacit knowledge refers to forms of personal knowledge that are difficult to express linguistically.
>
> *The participation perspective* considers tacit knowledge as a fundamental aspect of human activity. From this viewpoint, tacit knowledge relates to interactive processes involved in social participation as well as habitus transformation (Bourdieu, 1990, p. 24–5), a pre-requisite for transformative learning.
>
> *The knowledge-creation perspective,* in turn, addresses tacit knowledge from the perspective of systematic, focused pursuit of novelty and innovation, and trans-formation of social practices. Here an important role is given to the tacit knowledge one develops in the pursuit of trialogical objects, while trying to go beyond the prevailing epistemic horizon. A significant tacit dimension is also indicated when producers with practical concerns seek deliberately to transform their knowledge practices toward more innovative ones.

All three levels of tacit knowledge have an important role in trialogical learning, and innovative knowledge practices must be based on deliberate capitalization on tacit knowledge. Various technologies may be used to assist participants in handling tacit knowledge in their educational and professional activities. The above three metaphors of learning structure KP-Lab's approach to tacit knowledge. While the metaphors provide a useful way of examining various technologies for extracting and working with tacit knowledge, it is essential to bear in mind that boundaries between the metaphors are permeable and a given type of technology may be used for multiple purposes.

The knowledge acquisition perspective addresses tacit knowledge in terms of individual knowledge representations.

A1: Externalize ones' ideas, thought, and fuzzy intuitions

A2: Identify, analyze, and model patterns of activity

A3: Record knowledge practices, reflect on activities, and follow experiences across contexts

The participation perspective addresses tacit knowledge embedded in interactive processes taking place within social communities as well as the transformation of the participants' habitus.

P1: Constantly being aware of fellow inquirers' activities

P2: Elicit interaction between users, and enable reflection on interactive episodes

P3: Become reflectively aware of own prevailing practices and habitus

The knowledge-creation perspective addresses sustained processes of working with shared artifacts and developing trialogical objects across long periods of time (product plans, business strategies, marketing plans, theories, ideas, models, etc.)

C1: Create, modify, structure, visually organize, and manage versions of knowledge artefacts

C2: Collaboratively map ideas, and make own ideas objects of collective reflection

C3: Facilitate the transformation of collective practices

C4: Capture disturbances and tensions in prevailing practices, collectively reflect on observed critical incidents and crucial episodes

C5: Facilitate the evolution of epistemic artefacts by eliciting collective conceptualization of past, present, and future activity around trialogical objects

KP-LAB TOOLS FOR TACIT KNOWLEDGE

Based on the previous framework, KP-Lab designed a set of software tools to support operationalizing tacit knowledge in trialogical learning, tools and practices. We briefly describe here three such tools: the so-called "knowledge practices environment", the collaborative semantic modeler, the semantic annotation tool.

Knowledge Practices Environment – KPE

KPE is a virtual collaboration space that supports personalisation, temporal and faceted views to describe and visualise knowledge artefacts, their associations and state in different arrangements. KPE manages personal and collective spaces of knowledge artefacts allowing users to view knowledge artefacts in different ways and work according to different practices. A collective space is created for the knowledge community involved in a trialogical process. Users can browse and access content of a shared space through various views. A view is a graphical way of looking at the structure of information contained in a space. Three different views are possible: content view, process view and community view. The user is provided functionalities to handle the views and their contents, e.g., Fig. 2.1.

– Working with knowledge artefacts (creating, editing, storing, sharing, commenting, annotating semantically)
– Managing knowledge processes (creating, changing and executing process descriptions)
– Managing shared spaces (configuring access rights)
– Modifying the views of information

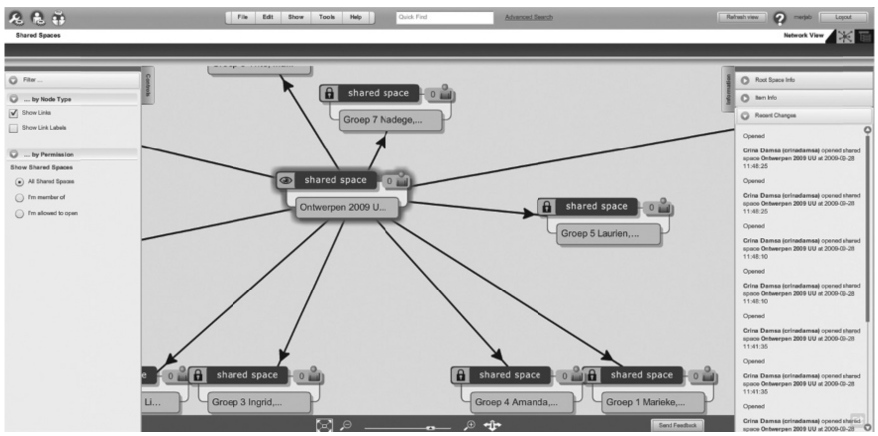

Figure 2.1. KPE shared spaces view.

Through these activities, the tool provides ways to capture and share tacit knowledge, especially by:

– Sequences of comments, authors of comments, timing of comments
– Nature of commented content items
– Concepts used when linking items
– Ways of positioning knowledge artefacts
– Tags used for particular content items
– Usage of knowledge views

To sum up, KPE has been designed on the basis of certain principles of tacit knowledge. In the knowledge acquisition perspective, KPE enables the externalization of ideas, the work on patterns of activities, and the recording of knowledge practices and their monitoring in different contexts. In the participation perspective, it supports awareness, reflection on interactions, and reflective awareness on ones' own practices. In addition, KPE is well suited to working with epistemic artefacts, according to the knowledge creation perspective. Therefore KPE provides means for backing up tacit knowing related to knowledge acquisition, social participation and collaborative knowledge creation.

Collaborative Semantic Modelling

The collaborative semantic modelling tool permits the collaborative development and exploration of visual models as well as that of visual modelling languages (Richter, Allert et.al, this volume). The tool allows for a controlled evolution of a modelling language, preserving consistency in time. With this tool, the users, individually or collaboratively, can choose between different modelling languages and work with multiple models simultaneously. This makes it possible to approach a shared-object from different angles and create multiple representations for a given phenomenon. Furthermore, the tool assists users in creating a common ground by enabling the specification of visual models and the semantics of the modelling elements.

Typical scenarios include settings where users aim at describing their understanding of an object in the form of graph-like visual representations. As such, the modelling activity is rarely an end in itself, but instead embedded in more overarching activities like collaborative planning, design, inquiry or evaluation (i.e. trialogical activities). Accordingly, objects of interest might include, for example, diverse kind of processes, logical and causal relationships or organizational structures which can be represented for example as flow-charts, argument-graphs, organigrams, decision trees, or program logic models (Busch et al., 2003; 2001).

Even though collaborative semantic modelling provides first and foremost a means for the externalization and materialization of explicit knowledge, several authors have argued that the materialization of mental models (for example as texts or diagrams) is itself a productive process and goes beyond the mere replication of the mental model (cp. Hanke, 2006; Engeström, 1999b). For example Stylianou (2002) discusses the role of external representations in problem solving activities and conceptualizes model creation as a continuous process of visualization and analysis. Similarly, Hacker (2002) discussed the importance of external representations for constructive engineering tasks, pointing out that multiple representations, as well as failures in the attempt to externalize mental models, might trigger reflection and help to elicit otherwise tacit knowledge.

Against this background it seems plausible that collaborative semantic modelling can contribute to the discovery and collaborative materialization of otherwise tacit knowledge in various ways:

- The externalization and materialization of mental models allows the individual or group to inspect and scrutinize these models from the “outside” and hence might foster the detection of blind spots or hidden premises.
- The externalization of mental models requires the individual to translate his/her ideas into a more or less well-specified visual-language and thereby might open up new perspectives for the object of activity.
- Furthermore, the use of multiple visual models as well as different visual languages might foster the detection of otherwise unrealized interconnections or contradictions and might help to understand the different perspectives implied by different languages better.

- The use of multiple visual modelling languages and related ontologies opens up an opportunity to explore various forms of tacit knowledge when used in the collaborative analysis of features and processes of videotaped activities which are otherwise beyond the reach of the analyzers' conscious reflection

In summary, this tool implements principles of externalization and awareness at the first two levels of learning, whilst providing interesting means to support the tacit dimension at the level of knowledge creation. It particularly emphasizes work on epistemic artefacts and reflection on ideas considered as collaborative objects.

Multimedia Annotation

Various domains are characterized by knowledge intensive collaborative activities such as research, technological innovation, and medical diagnosis, among others. The analysis of such processes for the purpose of modelling or transformation is a difficult task. Video recording of collaborative activities provides a means to capture individual and group behaviour and simplifies the analysis of work activities (Suchman & Trigg, 1992). The resulting video records are rich media that incorporate various facets of knowledge. Among these, practices and dialogues (Tsoukas, 2009) are the most salient forms of tacit knowledge. Analyzing videos to extract knowledge has traditionally been reserved for highly specialized people. Providing agents with means to analyze video records of their own activity or others has a number of potential applications.

The semantic multimedia annotation tool has been designed according to the principles of our conceptual framework. A group of users is provided with a video record of a given activity. The latter might be the users' own past activity, or that of others. The tool makes the use of free comments, formal domain discourse models, or other artefacts possible. Users can anchor comments or model items (concepts, events…) to specific fragments (or hot spots) of the video. The tool provides functionalities to manage media, participants, models and annotations. Technically, it is designed to import, store and export models and annotations using OWL (Ontology Web Language), RDF (Resource Description Framework) or plain XML formats. Processing tools implement various semantic inference methods to support activity analysis.

Two possible scenarios can be implemented. The first consists in asking the group to observe the video and to comment events, practices, singularities, or other aspects of interest. Users make use of annotations individually to share their findings. Group members are brought together to share their annotations and negotiate a common understanding. They are provided with annotation processing tools such as search, mining, comparing, and classifying. They create sets of agreed, disagreed and undecided annotations. This process is repeated to iteratively build a model of the underlying activity or design a knowledge artefact (e.g. a solution to a problem). This iterative and incremental cycle is a way of implementing a group dialogue where individuals become aware of their practices, by means of reflection, whilst working on a shared object. The knowledge artefact (e.g. a model) created from an initial episode can be refined throughout episodes and reused for the analysis of future activities.

The second scenario consists in providing the group with a formal model of the underlying activity. The model can be the result of the previous process. They would be asked to map the model onto the actual activity depicted by the video. The members relate the concepts of the model to the video content, individually. The group shares the individual productions and makes use of annotation processing tools to negotiate a common understanding of the video content. They discover discrepancies between the activity and the model and suggest transformations of the practices and the model. The result would be a continuously evolving shared artefact.

Example applications of these two processes include: individuals becoming aware of their practices (Fig. 2.2), comparing own practices to those of peers (or experts); learners internalizing knowledge embedded in the media; analysts uncovering knowledge practices prevailing in a community of practice; groups collectively reflecting on their practices and becoming aware of their habits. As such, the tool has been designed to support tacit knowledge in the knowledge creation perspective of learning. It enables working with epistemic artefacts, collaborative objects of reflection, transformation of practices, and analysis of tensions and disturbances.

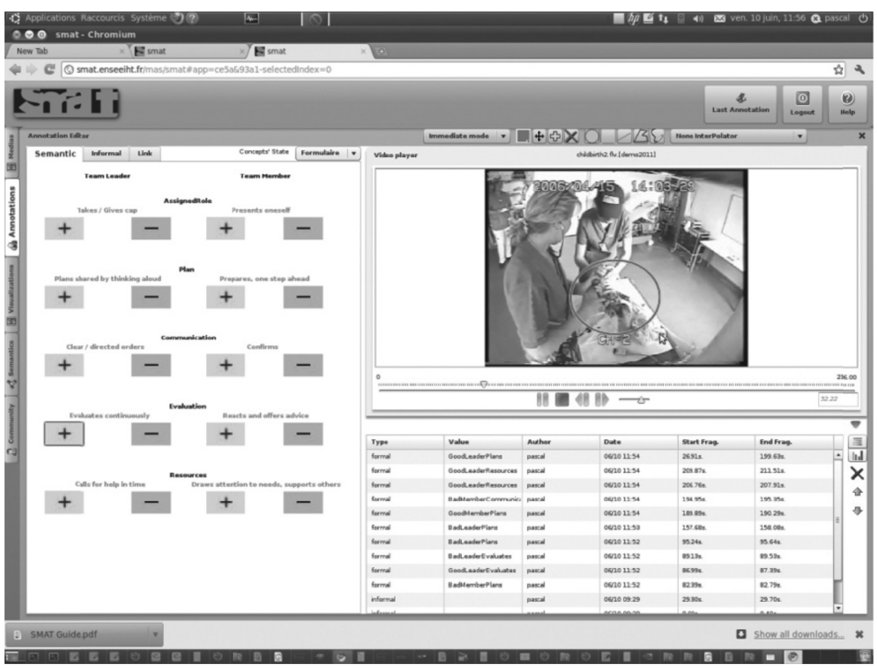

Figure 2.2. The Semantic Multimedia Annotation Tool's (SMAT) annotation view.

To conclude on the analysis of these three KP-Lab tools, i.e., KPE, visual modelling and SMAT, the trialogical approach is based partially on the assumption that tacit knowledge plays an essential role in learning according to different perspectives. Various knowledge acquisition processes rely on personal knowledge that is difficult to make explicit without specific tools, instruments, and practices. Moreover, diverse processes of social participation involve a tacit dimension, the explication of which makes the interactive processes visible and subject to deliberate reflection. In addition, deliberate collaborative efforts of knowledge creation capitalize on tacit knowing that guide the construction of trialogical objects and assist in selecting productive lines of inquiry. The present investigators and their colleagues have developed technology-mediated tools and instruments that assist learners in utilizing their tacit knowing and facilitate their reflection-in-action. We consider the above tools merely as the first steps toward developing technologies for utilizing tacit knowing in collaborative learning processes. The KP-Lab project has also created other tools, such as the "Activity-System Design Tool" (ASDT), which are not addressed here, but open up interesting novel opportunities (Toiviainen et.al., this volume). While evaluating the above instruments, it is essential to remember that the tools do not work without supporting knowledge practices (i.e., social practices related to tool usage), which significantly transform learning processes. In order to take full advantage of tacit knowledge, it is essential to make active utilization of the present tools as an integrated aspect of participants' everyday activity.

CONCLUSIONS

The aim of this chapter has been to position tacit knowledge within the KP-Lab learning paradigm. A short review of the origins of the concept and its interpretations focused on the seminal works by Polanyi and Nonaka. A link was then established from tacit knowledge as a concept, to collaborative knowledge creation processes, using Bereiter's notion of conceptual artifacts.

The chapter has also provided a review of technologies for supporting aspects of tacit knowledge. Artificial intelligence and information systems approaches were analyzed. Emphasis was placed on recent approaches based on forms of knowledge other than traditional formal explicit knowledge.

The proposed conceptual framework for relating tacit knowledge to trialogical learning was then presented. This is based on tacit knowledge dimensions in the three perspectives of trialogical learning, namely *knowledge acquisition*, *participation*, and *knowledge creation*. Based on these principles, we described the capabilities of three KP-Lab tools to support tacit knowledge.

Further investigations will focus on the operational aspects of the proposed framework by more thorough analysis of KP-Lab tools. Taking into consideration the various forms of TK would be a way of improving the framework. Furthermore, it would also be interesting to study the feasibility of defining a lifecycle for tacit knowledge within trialogical learning.

NOTE

[1] The presentation of models of ”innovative knowledge communities” are from Paavola et.al.,2004.

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3. REFERENCE ONTOLOGY FOR KNOWLEDGE CREATION PROCESSES

INTRODUCTION

Our aim is to understand how people collaboratively, in long-term processes, develop novel epistemic things and transform their knowledge practices, specifically by cross-fertilizing professional and educational practices and solve complex, authentic problems with the help of innovative knowledge practices and educational technology. We rely on the assumption that modern information and communication technologies not only facilitate knowledge creation around shared objects, but also promote the need to develop a 'trialogical' approach in learning and knowledge-intensive work. In this context, the focus on collaboration and support of discourses among groups of knowledge workers and learners rather than on automated reasoning by employing classical AI machinery. The great challenge then is the *understanding* and abstraction of *a large variety of seemingly dissimilar knowledge creation processes and products*, such that a set of generic but easily configurable tools can be deployed and integrated on a customized basis. This is crucial in order to understand learning and working as collaborative knowledge creation with increased ownership, to learn how to improve agency by scaffolding different mediational means, and to understand processes in which activities in different institutions and groups influence each other. In a nutshell, knowledge creation processes not only include things and facts, but also affordances to reflect and act adequately in a professional or educational environment (so-called *practice transformation*). Toward this end the major obstacles are:

1. There is no general theoretical understanding of knowledge creation processes and their forms of evidence in such settings
2. Existing collaboration tools offering complementary mediation affordances are highly specialized to particular formats and processes
3. Due to this lack of formal foundations on both sides, studying the impact of the trialogical learning metaphor for the KP-lab information system design is very challenging task.

We are confronted with a classical problem of requirements engineering in a domain completely new to computer science at this level of genericity. We approach this problem by bottom-up ontology engineering from an empirical base of representative KP-Lab-use cases of sufficient diversity. Since the project has

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started with particular IT demonstrators and pedagogical observations from controlled experiments, the consortium has collected an impressive body of empirical material that allows for objectifying the ontology engineering process and verifying claims of genericity in real settings. As usual in more general forms of requirements engineering, first a 'business model' of the domain is established in the form of a formal ontology. It comprises an understanding of the *roles* of people interacting in the respective business areas (see also the notion of 'niches' (Berman & Semwayo, 2007)), of the kinds of *objects* and products they deal with, and, finally, of the *processes* involving these roles and things. This model will also serve to identify the things that need to be implemented with digital equivalents in order to support the various knowledge creation-related services of the KP-Lab platform. Because the core of the platform is a knowledge repository[1] (Masolo et al., 2004), a quite direct translation is possible from an ontology pertaining to things and facts of the described reality to an information system model pertaining to the respective digital equivalents and additional management functions for the latter (Kotzinos, Flouris, Tzitzikas, Andreou & Christophides, 2008).

We use a sort of bottom-up/top-down methodology, where we first induce from a sufficiently diverse sample of specific models more and more generic concepts, and then back-propagate the generic concepts by re-engineering all information models of the various collaboration and communication tools available in the KP-lab Environment (KPE), which were initially conceived in a more intuitive way. The resulting ontology is not a product of intellectual invention, but the result of a controlled knowledge engineering process from a well-defined empirical base – i.e., the data structures that emerged in the KP-Lab tools developments, which in turn are based on relevant good practice in the domain. In particular, a certain lack of specificity and constraints compared to other models is the result of positively observing a relevant variability of the respective concepts from application to application and blurring boundaries between theoretically discrete steps in pedagogical processes. Further, we exploit the experience from other empirically-based ontologies and try out to what degree they fit the KP-Lab empirical base, reusing existing concepts to the degree that does not compromise the logical consistency and ontological commitments of the empirical level. In particular, we refer to the CIDOC CRM (ISO21127) (Crofts, Doerr, Gill, Stead & Stiff, 2009) for some very general concepts that we reuse as appropriate.

The back-propagation step in the ontology development serves as verification of the initial generalizations, and consequently leads again to refinements and adaptation of the whole reference model up to the top. This iterative process of ontology development has been repeatedly described and questioned in literature (Dellschaft et al., 2008; Gomez-Perez, Fernandez-Lopez & Corcho, 2004; Kishore, Zhang & Ramesh, 2004; Pinto & Martins, 2004). There are other approaches that use automatic building processes and are not based on iterative methodology, (Shamsfard & Barforoush, 2004). We maintain that the iterative one is the only ontology-development process that stands real-life validation.

At the time this chapter was written, we had finished the first abstraction and back-verification process of the KP-Lab Reference Ontology[2]. It is a formal ontology in the sense of computer science (Guarino, 1998), meant to support information systems design and operation. This is in accordance with our general objective to 'design innovative tools to support tacit knowledge' and not to model tacit knowledge theories themselves. In other terms, the formal ontology was created to allow the creation of effective knowledge creation tools, and not to justify in a positivist way the theory behind it. The latter would also not be accessible to the empirical ontology engineering methods we apply. The restriction of the ontology to relatively 'material' concepts, hence, is not a result of a positivist attitude but an inevitable consequence of the task to mediate between the intellectual realm and digital information systems, which can only be done based on the material forms of evidence and externalizations of mental processes.

Pedagogical processes as observable activities and phenomena may be still further elaborated ontologically, but the upper level of the model can be regarded as fairly stable and is, as such, innovative enough to be subject of publication (see Figure 3.5[3]). In the sequel, we describe the model in a top-down fashion, *opposite* to the actual process of its development. As we see in Figure 3.1, the core of the KP-Lab Reference Ontology allows us to reason about 'who did what and with whom, or wants to do what'.

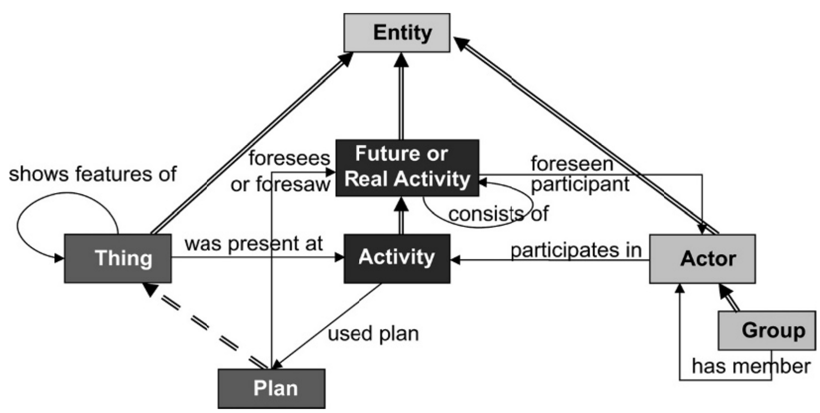

Figure 3.1. The high-level of the KP-Lab Reference Ontology: Thing, Activity, Actor.

KP-LAB ONTOLOGY AT A GLANCE

The major tasks of the KPE is to support the planning, supervision, and monitoring of knowledge creation and knowledge mediation activities and their products, as well as the subsequent *analysis and self-reflection* of knowledge workers on past performances, leading to revision of settings and materials, design and redesign of the planned actions (Paavola & Muukkonen, 2009). Consequently, in Figure 3.1, we present a first phenomenological core view of our universe of discourse as consisting of *anthropocentric processes* rather than of static analysis and classification of human products out of the human and spatiotemporal context.

In the KP-Lab reference ontology, we distinguish classes and properties in the sense of the knowledge representation languages proposed for the Semantic Web such as RDFS or OWL. Throughout this chapter we use, in our figures, boxes to denote classes, double arrows to denote relations of type 'subclass of' (a.k.a. 'IsA', or 'specialization of'), dashed double arrows to denote indirect relations of this type, and simple labelled arrows to denote a 'property' (a.k.a. 'attribute' or 'link') with a name as indicated by the label. We use 'strict inheritance' of properties along IsA relations, i.e. a property, such as 'was present at' does not only hold between 'Thing' and 'Activity' but also between all pairs of subclasses of the latter concepts. These 'inherited' properties are not represented in our figures because their number makes the respective graphs unreadable.

Any particular individual item in the scope of the reference model is regarded as an instance of an abstract class *Entity*, and therefore all other classes are subclasses of *Entity*. As in Crofts et al. (2009), any instance of Entity may be further classified by suitable terms – instances of *Type* – via the property '*has type*'. The distinction between the classes of the model and instances of Type is purely practical: the classes are the individual concepts carrying the relevant relationships that an application relies on, whereas instances of Types are used for taxonomic distinctions, frequently appearing as application data, as in the SKOS Schema (now recommended by W3C for terminologies or so-called Knowledge Organisation Systems, see Miles & Brickley, 2005). If appropriate, sufficiently stable, well defined and commonly accepted instances of Type may also be configured as ordinary subclasses of a suitable class pre-existing in the KP-Lab reference ontology. The advantage of this approach is that instances of Type can be more informal than model classes, and even fuzzy, without causing malfunctions in the KP-Lab system, since it does not functionally depend on their existence and definition. This is particularly necessary when knowledge work implies the intuitive conception and experimentation with new ideas and concepts, before or without understanding their formal properties.

The next level in the model can be described as 'people do things'. More formally, we distinguish three entities:

- *Actors*, i.e. people, with the capacity to actively or passively *participate in* activities. Machines are not Actors. Machines are neither responsible nor creative. Like all other tools, tools can only *react* on behalf of human intention and configuration. Collaborating people can form collective Actors, when they 'act as one'.
- *Activities* are real processes carried out by people of any scale – be it a lifetime of teaching or just pressing a button, comprising the processes induced by people such as running software on a computer or the snapping of a trap. Activities lay in the *immediate* or *remote past*.
- *Things* may be material or immaterial. Material things can be created, modified and destroyed, such as pens, desks, computers, houses. Immaterial things can be created or conceived, such as an electronic image, a poem or a meeting agenda,

but they can reside on multiple physical carriers at the same time, be it only in human memory. Their existence ends when the last carrier and the last memory are lost. Things can *be present at* Activities, at their creation, during use, modification or destruction. Immaterial things are present at activities via any of their physical carriers, which are Things in their own right.

All three entities have specific part decomposition forms:

- Actors form hierarchies of social *Groups*, temporary or permanent aggregations ('*has member*') of people capable of acting collectively. Some kinds of Groups may have only one member at a time, such as a political office or a persona.
- Activities may consist of Activities.
- Things cannot consist of arbitrary kinds of Things – material and immaterial components cannot be mixed. Therefore, part decomposition of Things takes place at deeper levels of specialization.

For our discourse, we denote here a few more very basic concepts. Things may *show features of* other Things. This property is the most general form of similarity. Besides others, it generalizes in an objective way over the important relations of derivation, versioning and logical continuation ('*is successor of*') of documents (Doerr & Bekiari, 2008; Doerr et al., 2008). Whereas physical objects undergo a history of physical modifications and alterations, immaterial objects do not 'change' but are only derived or continued. The reason is that the previous form of what people may call a 'modified document' is not physically lost, as it is the case for a material object under modification, even though a computer operator may by chance destroy the original document after entering changes. So any 'change' to an immaterial object actually creates yet another object, be it a single bit change. Chances are that there are other carriers around of all precursors. Since the focus on the *knowledge artefact* and its *evolution* is of central importance in the trialogical framework, we need a very realistic model of the behaviour and life-cycle of these things with respect to human activities.

Most fundamental to professional human activities is the fact that they are normally based on *Plan*s, which are a kind of Things (immaterial ones), that can be used ('*used plan*') in an Activity following the plan in one way or another. In particular, the plan may *foresee* a *particular* Activity take place, which may or may not become reality. Whereas an Activity is by definition restricted to realized ones, sometimes there are such precise plans that one can decide if one particular activity that took place is *identical* with a particular planned one or not (for instance, announced university courses). The planned one will necessarily have fewer features than the real one, but will share the essential features of its identity. Based on this assumption, we have extended the notion of activity to the future: the class *Future or Real Activity* can be regarded as a generalization of Activity. When an instance is recognized as becoming real, it is acquiring the additional properties of reality and its classification is 'shifted down' to Activity, i.e. an ongoing or past one. Since *Future or Real Activity* remains the superclass of *Activity*, this reclassification is monotonous – a major requirement in such a knowledge repre-senttation system. One could introduce 'Abandoned Activities' as another subclass, but they play no major role in our study. If the fate of a future activity stays unknown, nothing inconsistent happens as long as we continue with the primary classification. It is worth noticing that future events are beyond the scope of the CIDOC CRM (ISO21127).

Among the KP-Lab-use cases there are several examples of plans for units of knowledge work that only pertain to *kinds* of real activities rather than instances, deliberately not being specific enough to map plans, one-to-one, to particular realizations, while other plans pertain to identifiable future activities. With the above innovative design, we provide the flexibility to consistently describe both sorts of plans and combinations of them. Most conceptual models for workflow systems and planning do not even distinguish between plan and realization, as, for instance, the model proposed by Kaleidoscope for abstracting collaborative learning script modelling languages (Hoeksema, 2004). This is adequate as long as the system is intended to reflect only the latest stage of intention at any one time. However, this violates the basic requirement of KP-Lab for the self-reflection of knowledge workers on past performances, which, besides other things, means to be able to monitor and access the deviations from the initial plans. In the next paragraph, we analyse Actors, Activities and Things in the generic context of KP-Lab, introducing another set of specializations of classes and properties.

KP-Lab People

People are denoted as Actors, distinguishing *Individuals* and *Groups*. Groups can be informal or formal aggregations of people but are always tied by sharing some activities and goals, in contrast to being just listed or observed. One community of KP-Lab users is social Groups in education, e.g., school classes, participants in industrial training or university courses. Other important users are professionals in typical business settings coming together in meetings for planning or problem solving sessions.

A topic of particular concern for KP-Lab is modelling *social roles*. There are at least three distinct senses of social roles (Masolo et al., 2004; Steimann, 2000):

1. bound substantially to an Actor for the rest of its lifetime, such as ‘professor’, ‘artist’, ‘mother’, ‘hero’, ‘criminal’, ‘Nobel Prize Winner’, which is best modelled by classification of the Actor with a Type;
2. an ‘accidental’ role valid for a certain activity, which is best modelled by a relationship between the Actor and the respective activity; and
3. a persona represented by individuals and treated socially like an individual, but not bound to the life-span of one individual or more, which is best modelled here as a kind of Group as proposed in Crofts et al., (2009), whereas Steimann, (2000) proposes a similar, more detailed model, but too complex for our needs.

Traditionally, distinctions of the roles of trainer and trainee are closely connected to profession, education and stage of career. In trialogical learning the idea is to break up such traditional ties, and to regard these roles as occasional to the particular activity, and people possibly playing dynamically with the roles even within the same activity. Therefore, in contrast to classifying the people themselves, these roles are expressed in the model by the optional upper relationship '*is supervisor of*' between an Actor and an Activity to associate respective activity-specific privileges with it, in contrast to being 'not supervisor'. Roles can be assigned and reassigned from subactivity to subactivity, and an Actor may play different roles at the same time in concurrent activities. More specific KP-Lab application tools may refine these occasional roles in any detail, such as 'meeting chair', 'observer', professional roles, such as 'tutor', 'director', 'system administrator', and personal abilities, such as 'designer', 'pedagogue', that are independent from particular activities should be modelled as specializations ('IsA') of Actor, or be expressed by terminology (*Types*). We have not encountered use cases requiring us to model personae, but this facility is built-in in the core model.

KP-Lab Things

The basic assumption of the trialogical approach is that users engage, monitor and reflect on their collaborative knowledge creation practices by exploiting either their direct experience or material evidence found in various forms of documents and drawings available in the KPE. As a matter of fact, arguments, opinions and insight information are structured collaboratively as material or immaterial 'knowledge artefacts'. In principle, knowledge artefacts may include physical models or constructions (as in architecture or fine arts), but the actual KP-Lab-use cases pertained rather to immaterial products, such as texts, GANTT charts and knowledge models which are produced either by commercial software (e.g. text editors) or special KP-Lab tools (e.g., Visual Model Editor) (see Figure 3.2).

The KPE aims to support a collaborative, distributed discussion and analysis of knowledge practices by providing an elaborated shared space of knowledge artefacts as well as facilities to trace their evolution (Papavassiliou, Flouris, Fundulaki, Kotzinos, & Christophides, 2009). In this respect, KPE is used to create and monitor *KPLAB Objects*, i.e., all immaterial things created and managed *throughout* their life-cycle via the proper KP-Lab software along with suitable graphical representations. Among those are knowledge models (*Conceptual Models*) and their elements in the narrower sense, in the form of nodes and links. The elements of these knowledge models are in general visible and accessible to the participants of a discourse via virtual *Shared Spaces* such that they can be edited at any level of granularity by the knowledge workers, provided the adequate access rights exist. KP-Lab Objects *consist of* KP-Lab Objects as proper parts, down to the element level (properties, classes, instances). These models are expected to evolve as collaborative efforts, and the system is expected to monitor the *argumentation process* being also captured by KP Lab Objects.

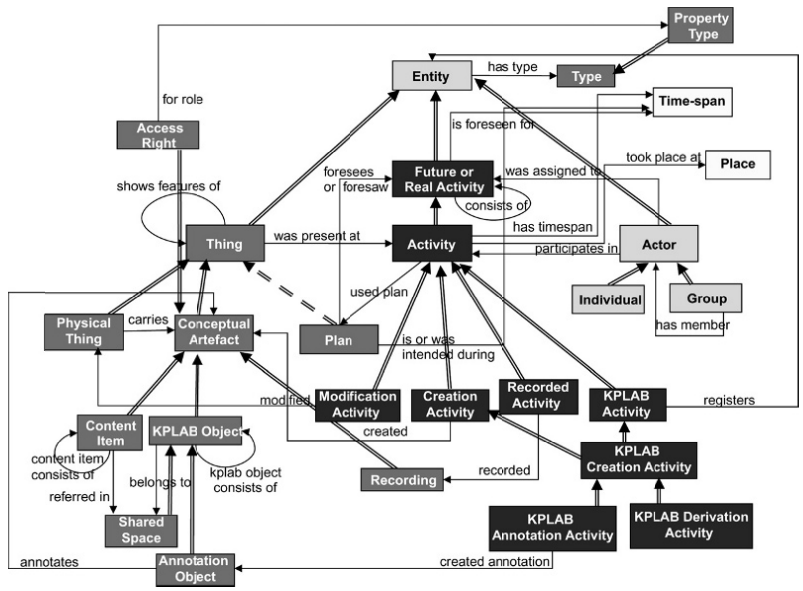

Figure 3.2. The KP-Lab Information System Reference Ontology.

In contrast, multimedia documents, the so-called *Content Items,* are of a more static, external nature in this respect. They can be registered and referred to by KP-Lab Objects, but are not part of them. They may be texts, images, video and audio recordings, CAD drawings, etc. Since their creation and derivation is under the control of external tools, their life-cycle cannot be managed by KP-Lab, but only be monitored. Any change in a Content Item is regarded as a new version, which does not make the original disappear. In that sense, they do not change. Content Items may have any origin or location, and KP-Lab users may create Content Items by any commercial software. Content Items, however, are regarded as being accessible by KPE for display with adequate invocable viewers or plug-ins, so that they can play an integral part of the KP-Lab user experience. They are described in KPE by digital 'handles' or surrogates, which are KP-Lab Objects in their own right, and an extended *Identifier*, referring to digital location, type and access methods ('behaviour' in terms of METS (METS, 2007)).

Content Items may have a structure and proper parts that users may like to discuss in detail. In order for the KP-Lab platform to be able to calculate access-right propagation, the parts of a Content Item need to be referred to by handles linked to the handle of their whole in a way consistently reflecting the structure of the whole Content Item down to the smallest units of reference needed. Thus, a notion of a structural model of a Content Item emerges, which could, in many cases, be generated automatically from tables of contents, etc. and be imported as read-only KP-Lab Object of reference. The video segmentation tool of the SMAT demonstrator is a good example of such a structural model generator. The METS metadata standard (METS, 2007) contains a quite comprehensive suite of modelling elements for structural models (the <fileSec>, <structMap> and <structLink> sections), which could be adopted and translated from XML Schema to RDFS and incorporated into the KP-Lab model.

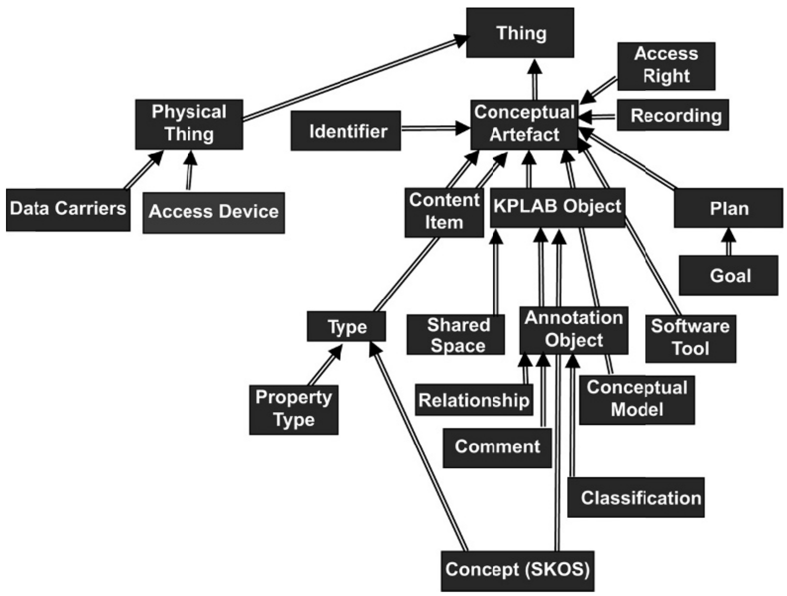

Figure 3.3. Thing Classification.

In a similar way, KP-Lab users may refer to any KP-Lab *Thing*, being digital or material; only – for obvious reasons – there is no mechanism currently foreseen to 'fetch and display' a material object to a user's work place equally as directly as a digital object, even though robots such as the physical model generators (Graham-Rowe, 2008) could easily be deployed together with KP-Lab tools. All other Things the KP-Lab reference ontology needs to distinguish are immaterial, and we comprise them under '*Conceptual Artefacts*'. KP-Lab Objects, Conceptual Models and Content Items are ('IsA') Conceptual Artefacts (Figure 3.3). Conceptual Artefacts may consist of statements *refer*ring *to* any Entity. Our notion of *reference* here is quite general: it may be phrases of a text, but also a depiction of something, realistic or symbolic.

The notion of 'Conceptual Artefact' plays a key role in the pedagogical discourse. Conceptual Artefacts are both the frequent focus of attention in pedagogical goals and activities, and the objective outcome of and evidence of conceptual activities. Even though the notion of conceptual artefact (or 'knowledge artefact') may, in pedagogical literature, be overloaded with notions of other things not 'artificially made' (what the term generically means), we use it here in the restricted, clear meaning in order to avoid ontological ambiguities. The key notion of 'object of activity' in the trialogical approach is interpreted ontologically in our context as being a dependency rather than of individual substance, i.e. as a relationship between an object of arbitrary nature and an activity focusing on it. This is comparable in nature to the well-known *subject* or *aboutness* relationship in library science (Doerr & Bekiari, 2008; Doerr, et al., 2008) and, therefore, we rather call it *'subject of activity'*. The 'object' in this widest sense may be anything, as experts confirmed, and hence has no other ontological substance than 'Entity'.

Access permissions are regulated by *Access Rights* an Actor may *possess*, and that *apply to* a particular Artefact. The class Access Right must be suitably extended to describe individual rules, such as the rights implied by an Actor having created an Artefact. It is not the intention to encapsulate these rules with formal logic, but rather via procedural code. The ontology would only refer to the kind of rule by a name. Access Rights may in particular be specific for the occasional role of an Actor in an Activity, which is represented as a relationship. Hence, to model the components of such a right that appear as KP-Lab Ontology elements, we need to refer to schema properties as instances ('data'). Therefore the class Property Type specifies the kind of role in an activity that an Access Right pertains to, which can be instantiated by the adequate term.

In order to talk about an *Entity* it must be identified by some name: an *Identifier*. In an IT environment, users are forced to select one primary identifier in the scope of a local system, which is typically identical to the node representing the object in the information system. Besides that, an Entity may be referred to by any number of unique *Identifiers* without causing confusion, as long as the identifiers are not confused with the use of a primary identifier to represent the object itself (Meghini, Doerr & Spyratos, 2008). This is particularly helpful for integrating independently-created models: Two nodes representing the same object can be merged, but all their Identifiers are preserved. Registering non-unique identifiers, such as 'Mona Lisa' helps in finding things in uncontrolled environments.

Roughly speaking, KP-Lab Objects can be divided into proper knowledge-representation elements, such as concept classes, terms, links and nodes representing real-world items, and, on the other hand, *Annotation Objects*. Annotation Objects are neither objects used to annotate nor the objects annotated. Rather, they consist of the *propositions* made to annotate something. They are key elements used to monitor a discourse. They have a historical dimension. They are created in an *Annotation Activity*, and may be created as derivative of another annotation (a *Derivation Activity*), or even be withdrawn, but should not disappear as a historical fact from the system. They express an opinion and are specific to a user and dependent on the items the annotation has brought into a relationship. In general, an Annotation Object expresses an n-ary relationship between things, be it KP-Lab Objects or real world items. There can be an extreme variety of specific annotation models with particular constraints (Constantopoulos, Doerr, Theodoridou & Tzobanakis, 2004). The typical constituents are relations of content items and their surrogates, with terms and parts of conceptual models. Examples are (Constantopoulos et al., 2004):

- Textual comments about a thing
- Classification and rating of things by terms, such as SKOS Concepts (Miles & Brickley, 2005)
- Comparison of multiple parts of content items
- Typed linking of parts of content items
- Comparison of multiple relationships between things, such as drawing analogies.

The idea is that KP-Lab application tools (e.g., SMAT) will create their custom annotation models on demand. In the core model, we only refer in an unconstrained way to a choice of basic relationships, namely '*annotates*', '*with concept*', '*is about*', '*comments*', '*links*', *'links with'*, which are intended to be restricted to particular annotation *Types.* KP-Lab Objects and Content Items are the formal products described in the KP-Lab use cases, which are envisioned to be created by KP-Lab *Software Tools* and are also regarded as Conceptual Artefacts.

Besides that, any activity executed with the help of a KP-Lab tool is expected to be based on a *Plan*, evidence of which may or should be captured by the KP-Lab system in order to support inferences on the relations of the plan to its realizations. Plans are also Conceptual Artefacts. A particularly important kind of plan is a *Goal*, which we identify as the plan to achieve a particular state of affairs, such as 'having a finished plan' or 'having finished the paper about the KP-Lab ontology'.

KP-Lab Processes

The heart of the knowledge processes KPE aims at supporting are the planning, modelling and problem solving, which are collocated with, associated and accompanied by a series of physical and social processes. We can distinguish four basic goals for which we want support from an information system and therefore need a model of the related processes:

- Instructors and professionals need to *prepare* for *Units of Knowledge Work*, typically in a documented form
- Instructors and professionals *wish* certain activities *to happen***,** i.e., to be *Future Activities* with distinct properties
- Participants of activities, including instructors, wish to *participate* in certain virtual, shared activities using some *Access Device* over the Net
- Instructors and trainees want to understand *what has happened* in a *Unit of Knowledge Work*, reflect on it and draw conclusions

For modelling processes, we follow the well-tested modelling pattern of the CIDOC CRM, connecting time information exclusively through 'perdurants' or occurrents (Gangemi, Guarino, Masolo, Oltramari & Schneider 2002), in particular events/activities, with Actors and Objects being present at the respective events. As of now,, we consider that relevant occurrents are only Activities, i.e., events happening on behalf of human initiative, and therefore do not introduce other superclasses of Activity as in the CIDOC CRM. So, generalizing, we encompass all processes under the notion of '*Activity*' (Figure 3.4), carried out collectively or individually by some Actors in the physical *presence of* other participants and things, like pens, tables, computers and information carriers. In general, an Activity may *use* any-Thing, but a particularly distinct role-play *Plans* and *Software Tools*. Actors may create *Conceptual Artefacts* in a *Creation Activity* by software tools following a plan. A Plan may be specific to particular use, or reusable, describing a certain pattern of types of activities to be done.

The preparation of units of knowledge work implies the choice and definition of the goals and structures of these units and the methods to be used (the so-called 'scaffolding'). It results in the *Creation* of preparation documents, *Plans* in the wider sense. If they are only for the instructor and general information of the students, all these can be produced with normal text editors, even though smarter tools proposing adequate information structures and supervision functions can be thought of. Further, instructors need to *create* presentation and handout materials, also with traditional tools. It all boils down to document creation. The KP-lab platform can handle adequate metadata and inform the trainees in due time about the relevant contents. In case multiple instructors wish to collaborate on the preparation in a CSCW settings (e.g. using Google Docs), the preparation itself should be regarded as collaborative knowledge creation activity as described in the following, with its own 'metaplanning' as previously described. Therefore, it does not constitute another distinct pattern of work.

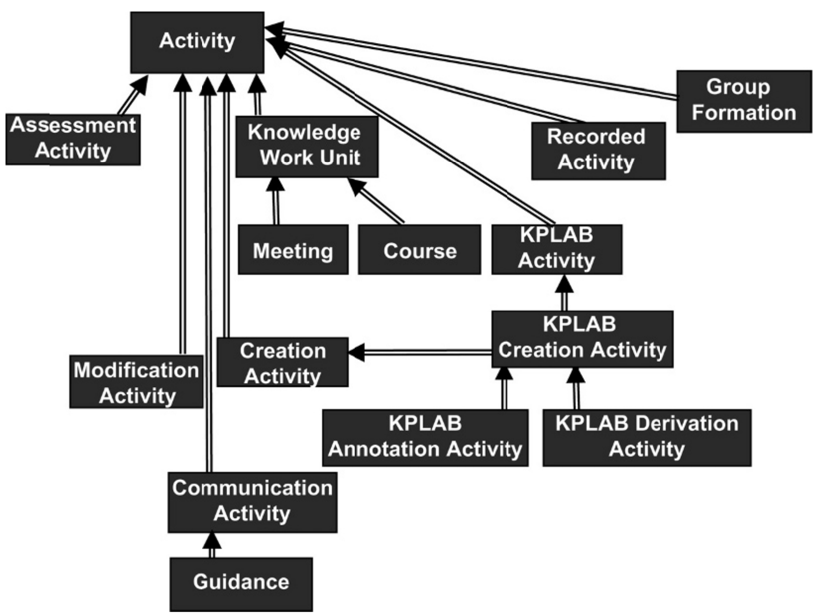

Figure 3.4. Activity Classification.

The degree of precision with which instructors and professionals may wish the planned activities to happen can vary greatly. The more detailed pedagogical scenarios are determined by elaborate planning, either before or as part of targeted activities, guidance and intervention. They are accompanied by observation and followed by analysis, which may result in the creation of other artefacts and planning of new activities. KP-Lab-use cases cover an immense variety of strength of control, but at least a unit of knowledge work as a whole is normally planned explicitly as a *Future or Real Activity*. As for the internal structure of these units, all variations are possible:

- to leave the structure completely to chance, intuition and group dynamics;
- to enforce certain '*Milestones*' terminating phases without preconceived structures; to suggest but not enforce a certain structure;
- to enforce certain activities without preconceived order (e.g., iterations; to enforce a structure of sequences of discrete activities;
- or to use any combination thereof.

Enforcement of plans is done either by prescription in a *Plan* that is *used* for the planned activity, i.e., handed out to the participants and characterized as valid or, by active *Guidance* by instructors during the activity, as adequate. Note that in particular multiple activities may concurrently occur without a particular coordination between them. Any model based on states with explicit transitions (such as various workflow or CSCL script languages) fails to describe such spontaneous situations. Such a lack of more constrained structure requires a rather general model with generic elements of future activities and possible order between them, which can be specialized to more constrained settings according to the application case. For managing learning and knowledge creation, the ability to monitor and self-reflect is much more important than to ensure a particular execution sequence. The KP-Lab model is accordingly unconstrained.

All activities can be seen as meetings of things and people in space-time, but we distinguish in the common social sense *Meetings* and *Courses* as some major subdivisions. Activities may consist of other Activities, such as lessons, tasks, sessions, etc. This hierarchical *part-of* relationship (which is inherited) is paralleled by a causal/temporal association: an Activity may be *continued* by another. We assume that continuation implies that the *continued* Activities form part of (the inverse of *consists of*) of a larger whole. These relationships form only a generic pattern for further specialization into quite elaborate flows of creative work sessions and associated activities.

The most extreme cases of preconceived control in e-learning environments are the SCORM-based applications. SCORM (ADL, 2004) is a standard for interoperability of learning assets for partially- or completely-automated courses with all forms of interactions preconceived. It is clearly not the intention of KP-Lab to compete with these, but rather to cover a continuum with the more dynamic and spontaneous side of training, and still be able to offer substantial information services. This implies that, ultimately, SCORM patterns could fit as specializations under the KP-Lab Reference Ontology. Most generally, a *KP-Lab Activity* is an

Activity registered by the KP-Lab platform in the course of set-up, monitoring and control processes. *Machine events* or 'actions' (rather than only 'reactions') are regarded as happening on behalf of (the responsible) system users and, as such, are regarded as parts of human *Activities*. Analysis of registered activities and artefacts will provide the evidence of the epistemic/intellectual/social phenomena taking place in and between humans to enable self-reflection.

Participants of activities, including instructors, who wish to *participate* in certain shared ('KP-Lab') activities via some *Access Device,* have the possibility of being registered and of being informed about goals, items under elaboration and other participants. The *Shared Space* represents the virtual simulation of sitting physically at one table and participating in the same discussion and elaboration of the same artefacts, in particular shared *Conceptual Models* and *Annotation* making.

Finally, instructors and trainees want to understand *what has happened* in the knowledge work unit, to analyse and draw conclusions. For that purpose, activities, interactions, (in particular *Communication Activities)*, and their outcomes should be *registered* and be seen in comparison with the initial *Plans.* Therefore the Model relates any document to its context of creation, intended use and actual use. From the KP-Lab-use cases it is very clear that the focus is not so much on enforcing preconceived plans, but to enable this *self-reflection***,** which *feeds back* into the planning of the next activities.

Consequently, a characteristic activity is the *recording* of what is going on for later analysis. In this core model we do not distinguish the recording action itself, i.e., the handling of some recording device, since this is just a special case of a Creation Activity using some tool we already sufficiently describe in generic terms. In contrast, rather, we model the *Recorded Activity* as an activity in which those being recorded and those recording simultaneously participate and interact. The relevant new property of a *Recorded Activity* is that it *creates* a *Recording* of *itself*. Indeed, operators of the recording may equally appear in the recording. Thereby we tie the recording into the context of what is recorded. The actual means – electronic or manual writing – play a secondary role. Via the *Recordings,* analysts may identify more activities than those preconceived or actively announced to the system by the users. In particular, trained pedagogues are able to analyse relevant *activity patterns* and their *transformations* from unit to unit, and draw professional conclusions from those (Engeström, 2001; Hoeksema, 2004).

COMPARISON WITH RELATED CONCEPTUALIZATIONS

Various conceptual models and ontologies have been devised for capturing information related to collaborative learning and working. One of main objectives of these models is the analysis of tasks occurring in groupware. They usually involve (a) task decomposition (structured activities indicating also time constraints), (b) task flow (ordering of tasks executed) in a workflow style and, (c) various forms of information objects. In van Welie, van der Veer, & Elens (1998) a task world ontology is proposed to model tasks independently of the graphical representation employed to visualize them. The ontology defines the *basic* *concepts* and *relationships,* instances of which need to be recorded by an information system in order to analyse groupware activities. The ontology is derived from the Groupware Task Analysis (GTA) framework[4] and incorporates the relevant aspects of several other task analysis methods. The basic concepts from GTA (*task, object, agent, role* and *event*) are related using specific properties (e.g., *uses*, *used by, triggers, plays, performed by, subtask, subrole, responsible).* This approach mainly focuses on an ontology that can be used as a link between task models and interface design models. *Task* is the basic concept and the selection and the definition of all other concepts depends on and is related to the tasks. The notion of 'task' in our model is defined as an activity, connecting also with actors, things objects and time. Activity, basically, is an Event, not just related to an event, as in a task model, because the separation of task and event causes undecidable ambiguities in practice. Role is not a class, it is a relationship. Our model is conceptually richer than a task model; it captures complex semantic relationships that connect endurants and perdurants, and represents not only the realization of activities but also the planning or the future realization of them (which cannot be represented by any existent task model).

On the other hand Suthers (2006) approach is concerned with the way knowledge construction activities are mediated by shared representations. More specifically, it examines how collaborating learners use software-based knowledge representations and, consequently, how to design such tools to support more effective collaboration. It relies on a methodology of qualitative analysis of workspace activities and builds on the concept of *uptake*. Uptake is defined as the event of a participant doing something with previously expressed information. Each uptake relation was derived from notational relationships between visible media events as well as temporal contiguity. Suthers (2006) investigates the role of representation changes in *online synchronous collaboration* rather than asynchronous interaction, as the ones studied in KP-Lab. The analysis is conducted in three phases: identification of individuals' actions in the media; identification of information uptake relations between these acts; and application of appropriate theoretical perspectives to interpret the uptake graph (interpretations of the intentions behind the references). Suthers (2006) emphasizes the importance of the representations mediating the interactions between participants in an activity system. In this respect, it identifies interactions such as conversations and conflicts but it does not analyse or use an argumentation model (such as in the KP-Lab Reference Ontology, a part of which enables the representation of argumentation and discussion processes through the Communication Activity class and its links), nor does it analyse or evaluate the design of the employed software. Instead, it relies on a graphical evidence map capturing representations of data, hypotheses and evidential relationships as a graph which enables participants to express the group's emerging consensus. In this work, we cannot identify specific types of events in the media transcripts that constitute an interaction, only the uptake events. Another negative is that the model of this work may need to be changed for different software interfaces, tasks, etc. which is a major limitation for building an open collaboration system such as the KP-Lab platform.

Other conceptualizations propose ‘open ontologies’ (Froehner, Nickles & Weiss, 2004) as a social approach to the modelling of knowledge heterogeneity and dynamics. Open ontologies emerge from and evolve with communication processes involving multiple knowledge sources and users, while they enable the representation and processing of semantically conflicting knowledge by means of reification according to the social meaning. They essentially provide a dynamic representation of socially annotated knowledge. They are dynamic ontologies since they evolve from communication processes and continuously need to be adapted. Additionally, agreement on concept definitions and a shared understanding is not always easy to achieve, given that agents’ needs and beliefs constantly evolve. In this respect, open ontologies and, consequently, open knowledge bases need to incorporate metaknowledge about the social contexts of the knowledge generation and usage, which needs to be predefined in order to use any tools for it. This is actually the role of the KP-Lab Reference Ontology. Things like ‘Open ontologies’ are regarded as subjects of activities in KP-Lab, as Conceptual Artefacts, comprised more specifically under *Conceptual Models* (Richter et al., 2009).

A related work also aiming at integrating various domain-specific ontologies into a single concise knowledge base is the Smart Web Integrated Ontology (Oberle et al., 2006). It uses a foundational ontology, called SmartSUMO, as a conceptual backbone to represent diverse ontologies developed for mobile and intelligent user interfaces. SmartSUMO relies on DOLCE[5] and SUMO[6] foundational ontologies. Each of the domain ontologies may be used in several parts of the system and, in order to be interoperable, they need to be integrated into a single knowledge base. A centralized design with conceptual clarity is used for modelling consistency. The abstract foundational ontology is used as a medium to facilitate domain ontology integration and defines ontology design patterns. This approach makes the building of new ontologies easier, provides a reference point for comparisons among different possible ontological approaches, and a framework for analysing, harmonizing, and integrating existing ontologies and metadata standards. This methodology is adopted by the KP-Lab Reference Ontology since we employ the core foundational concepts as a medium to integrate SMAT Application ontology, SSpAOntology and the conceptual parts from the pedagogical requirements.

Dellschaft et al. (2008) discuss existing standards and workflow models to capture the needs of collaborative scripting languages in pedagogical and software engineering domains. Even though many different approaches were examined (such as pedagogically annotated activity diagrams, conceptual models for collaborative learning script, vocabulary, active document approach, etc.), the conclusion was that it is difficult to cover all the needs from the pedagogical perspective up to the technical implementation. Specifically, the challenges were about how to model groups, artefacts, dynamic features of collaborative learning processes, complex process structures, control flow and types of social interaction. Although workflow systems offer technical support to learning process enactments, a more precise collaboration or coordination model has different requirements. Workflow-based visual models could not represent explicitly the pedagogical design and rationale. The difficulty was to find a representational model that fits all the perspectives: a model that can express social planes, shifting roles and different pedagogical rationales. On the other hand, the KP-Lab Reference Ontology seems to fit all the perspectives; it enables representing control flow/monitoring, different types of processes, social interactions and meetings, communication activities, pedagogical perspectives and learning activities, by specializing or enriching the core ontology with related concepts in a consistent way.

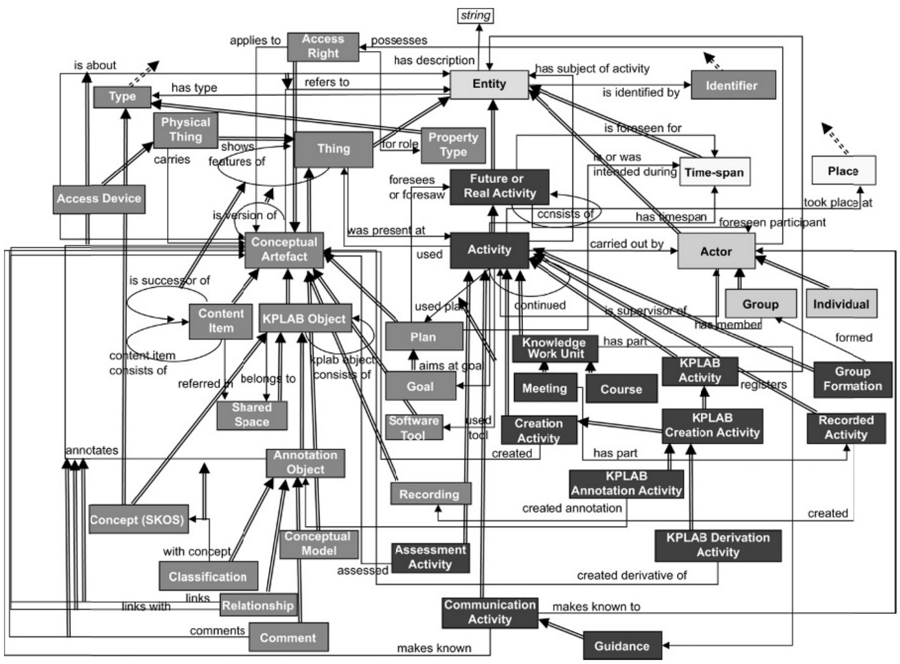

Figure 3.5. The Complete KP-Lab Reference Ontology.

CONCLUSIONS AND FUTURE WORK

The reference ontology described in this chapter provides a common language of general terms for a disciplined, collaborative user discourse on observed phenomena and their interpretations in knowledge-intensive work units. Rather than creating robot instructors, we are interested in KP-Lab in developing a generic platform which enhances human knowledge creation activities in the sense of an *administrator* of plans, activities, and created artefacts with access restrictions, a *mediator* of information assets and elements between distant parties and across time, of a *shared memory* and of an *analysis tool* for reflection and self-reflection on the success and effectiveness of past activities.

The evaluation of success of this ontology consists of the formal ability of the ontology to subsume and integrate the tool schemata and models of KP-Lab such that these tools can be used running on one coherent knowledge base in the sense of computer science, which serves the generic and particular information needs following trialogical guidelines and testbed specifications. This ability has been verified explicitly together with the partners. The method applied was the one of classical knowledge engineering. The human knowledge carriers – pedagogical partners and tool developers – were interviewed and confronted with critical questions until the ontological commitment of their intuitive concepts could be verified in common agreement (Guarino, 1998). The method is trialogical: the empirical materials were the knowledge products of the partners, texts, schemata, models, and the agreement was substantiated in the common formulation of the formal ontology: the 'knowledge artefact'. Concepts which could not be substantiated in an unambiguous form did not enter the ontology; rather, agreement on more general and more specific unambiguous concepts was sought in order to 'encapsulate' fuzzy or ambiguous concepts, and thereby make sure the unambiguous implications of these concepts can be used by information systems – which, due to their poor nature, are restricted to following logical instructions.

So, the adequacy of the ontology comes out of the empirical knowledge engineering process itself, the subsequent formal-logical integration of the KP-Lab models, and the ontological commitment of the latter's integration confirmed by their designers and users in the concepts, their subsumptions relations and the immediate deductions from them. A running database was created and the adequacy verified by adequate examples.

The KP-Lab Environment and Platform as well as the underlying reference ontology are carefully crafted such that they do not replace existing e-learning tools but, rather, complement them in the sense that the KPE can easily be interfaced and integrated with a variety of adequate tools for artefact creation and visualization. The ontology plays the key role in enabling interoperability between the various KP-Lab tools, as well as third-party applications. Therefore, it describes the core schema for data exchange between the KP-Lab tools implementing different specialized tasks and communication forms. It further describes the transitions between the external reality and the reality known to the KP-Lab platform, artefacts coming from third-party applications and those being managed in KPE. With this core ontology, we were indeed able to integrate quite heterogeneous and diverse applications as specialization under these very small and fairly generic concepts and properties, which will allow for the interchange of results between different applications so that they can be used in combination. As a matter of fact, it is only an upper ontology, abstracting from the core activity and artefact types taking place in rich and heterogeneous knowledge creation processes. This led to an empirically-driven generalization for integrating the information required by KP-Lab or external tools and for managing the characteristic life-cycles of knowledge artefacts in knowledge creation processes. It is deliberately extensible, and we expect, in the future, to provide more elaborated models for pedagogical analysis addressing typical cases of practice transformations.

In a nutshell, the KP-Lab reference ontology is a powerful integration means to elaborate theoretical ideas, technological development and empirical studies according to the trialogical metaphor. The KP-Lab ontology is an appropriate part of trialogical knowledge practices, because it helps to operationalize trialogical practices. In this respect it is exploited by the KP-Lab Data Protocol (Moen, Ludvigsen et al., 2009) which provides a coherent, descriptive framework for analysis of material evidence related to the empirical cases of the project. In particular, the protocol suggests a multi-level analysis approach with *micro*, *meso* and *macro* level data spanning different timescales and also allows capturing actions and productive interactions between the situations – micro level data; intermediate representations – meso level data; and the developmental trajectories pointing to longer-term, historic changes – macro level data.

In KP-Lab, the challenge for designing effective information system support is not the causal-deterministic modelling, which we found to be generally impossible or over-restrictive, but the effective guidance and monitoring of the learning processes, allowing for the subsequent self-reflection by trainers and trainees. Therefore, the KP-Lab Reference Ontology indeed represents a cognitive approach, modelling the phenomena and tangible products trainers and trainees are confronted with in order to effectively carry out processes following trialogical learning theory.

So the reference model can be used to identify and compare knowledge creation processes in case studies based on the recorded data. In order to be able to achieve the comparison and assure cross-model and case compatibility and comparability of the recorded data, the Data Protocols employ the reference ontology to formalize the design hypotheses about kinds of physical actions and productive interactions suitable to elicit intended behaviour in knowledge work participants. As such, the reference ontology supports integration of findings within and across case studies and provides a common language of exploiting heterogeneous knowledge creation processes and products.

NOTES

1 See the ICS-FORTH Semantic Web Knowledge Middleware (SWKM) at http://139.91.183.30:9090/SWKM/

2 See the KP-Lab Reference Ontology Wiki at http://athena.ics.forth.gr:3025/JSPWiki/

3 Shades if grey in figures stand for different representation of classes: the darkest grey represents things (physical or not); the medium grey represents activities; the lightest grey stands for time and place; and lighter grey for actors (regular grey represents an entity). Please see http://athena.ics.forth.gr:3025/JSPWiki/ for color version of the figures.

4 See http://www.cs.vu.nl/~martijn/gta/

5 see http://www.loa-cnr.it/DOLCE.html

6 See http://www.ontologyportal.org

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4. KPE (KNOWLEDGE PRACTICES ENVIRONMENT) SUPPORTING KNOWLEDGE CREATION PRACTICES IN EDUCATION[1]

INTRODUCTION

Many activities have moved to the Web, offering a medium for numerous everyday tasks related to home, community, office, education, etc. A constant flow of new tools, use trends, services and terminologies now forms part of people's daily lives (Candy, 2002). The landscape of tools changes constantly and the tools are complemented by a new generation of open source and access tools, social media tools, services, and enhancements. This includes tools for social bookmarking and note-taking (e.g. Diigo), community-building environments (e.g., LinkedIn and Facebook) and collaborative working tools build on wiki engines as well as photo-, music-, and video-sharing tools (e.g., Flickr, Vimeo and YouTube) (Väljataga, Pata & Tammets, 2010). The challenge of combining an appropriate solution to work, study and various other forms of practices is then constant.

The ability to reflect on how and where to acquire adequate resources and filtering methods, or to interpret received and found information and produce, collaborate, share, or modify knowledge have become central requirements for modern knowledge work and learning (Paavola et al., this volume). As Fiedler and Pata (2009) stated, the learners are faced with the fact that they have to select, combine and use various materials, online tools and services. This means that learners need to be guided and supported in their choice of learning trajectory including tools and resources (i.e., the learning environment) as well as provided with examples of tool ecologies and collaborative work practices with the tools. Furthermore, the set of tools and practices that these new opportunities allow influences the study practices of within the environment (Könings, Brand-Gruwel, van Merriënboer, & Broers, 2006; Entwistle & Tait, 1990).

Although many social media and open source tools may be useful and easy for a special purpose, the products and their manners of use are hard to integrate with other systems. The report on industry-led FP7 consultations "New Collaborative Working Environments (CWE) 2020" suggests in the summary that the integrative and interoperational elements do not belong among the characteristics of current Collaborative Environments. Anderson (2007) and Crosslin (2010) state that the challenge for tools, environments and sites that try to offer services for education is

A. Moen, A. I. Mørch, S. Paavola (Eds.), Collaborative Knowledge Creation: Practices, Tools, Concepts, 53–74.

that they need to incorporate APIs and other resources that can be powerful enough to be useful but at the same time should be easy to learn and use. The tools might not allow good enough metadata on the products to exchange materials between applications or to further revise knowledge artefacts collaboratively. Furthermore, most tools used for collaborative work and practices are based on approaches that do not support reflection, a holistic perspective, or a change in perspective (Conole 2010, for alternative approaches that emphasize the holistic, interconnected relationship between tools and users).

The present article introduces the Knowledge Practices Environment (KPE), a virtual environment aimed at providing some solutions to the needs and challenges mentioned above. KPE has been created to provide an integrated system and tools for supporting collaborative knowledge creation in which emphasis is placed on collaborative, iterative and sustained efforts to create artefacts and/or knowledge practices and processes together, and the role of the tool is to mediate the process smoothly and flexibly. Knowledge creation processes are a broader class of purposive and situated activities of a learning community (underlining such notions as object-orientedness) intending to develop knowledge artefacts and the trialogical approach (explanations and descriptions for more details from Paavola et al., this volume). This means that KPE is designed to support flexible ways of working with shared "objects".

BACKGROUND IDEAS OF KPE

KPE is a web-based application developed in the Knowledge Practices Laboratory project (KP-Lab), designed to provide specific affordances for working with shared objects; that is, joint development of knowledge artefacts[2] as well as for planning, organising and reflecting on related tasks and user networks (Markkanen et al., 2008; Lakkala et al., 2009). The features, design and interaction potential of KPE were derived using the co-design processes with several cycles to integrate theoretical perspectives, research-based pedagogical ideas, and technological development. The trialogical approach is a metatheory of knowledge practices, which provided means for transforming prevailing pedagogical practices in various contexts into direction of more sustained, collaborative knowledge creation mediated by technology. KPE went through several phases of co-design in which various intermediate abstractions and ways of instantiating theoretical ideas were used to guide the co-design process. At the start of the project, pedagogical scenarios and design principles of trialogical learning were produced (Paavola et al., 2011). The *design principles* were aimed at defining the general characteristics of trialogical learning for various courses and knowledge practices. The design principles of the trialogical approach highlight that collaborative activities are organized around developing shared objects (collaborative knowledge creation as well as transformation of knowledge practices) in sustained processes and with flexible tools supporting these processes.

The design principles were, however, not enough to direct and give scope to the technical development in the project. *High level requirements* were collected and defined on the basis of research cases and studies for explicating desirable functionalities of the KP-Lab technology from the end-users' point of view. The requirements were then grouped into *driving objectives* and *types of mediation* which defined general aims and the role of technology in collaborative knowledge practices (see further description of the process in more detail in KP-Lab, 2008).

In practical terms, the types of mediation were used to categorise the features, functionalities and *perceived* affordances of KPE tools into the basic functionalities that they were supposed to be supporting and enhancing (adopted from Rabardel and Bourmaud, 2003; also Hakkarainen 2008; Paavola et al., this volume). The types of mediation defined and used in the KP-Lab project are:

– *Epistemic mediation*: creating, transforming, organising and linking knowledge artefacts;
– *Pragmatic mediation*: planning, organizing and coordinating working processes;
– *Social mediation*: managing social relations around shared objects and linking people; and
– *Reflective mediation*: visualising of and reflecting on the work processes.

The principal requirement for appropriate tools to support trialogical knowledge practices was to enable *multimediation*, providing integrated and rich support for the various aspects of complex collaborative knowledge creation processes. The types of mediation provided an analytic outlook on the basic functionalities of the tools, but they are often very much combined and mixed in practice. Some appropriated practices intertwine the categories; for example, pragmatic mediation often becomes the source of epistemic mediation, and the organisation and coordination processes themselves are the objects, which are linked to other practices and attempts are made transform them. KPE is designed to support this kind of flexibility. In theoretical terms, the types of mediation can be classified into four main orientations in instrument-mediated activity (cf. Rabardel and Bourmaud, 2003) toward the object of activity, activity itself, other subjects, and oneself. The types of mediation thus aim at

– Getting to know the object, which equate to the epistemic mediations of the object;
– Practices on/above/through the object; namely, transformations, regulation management, etc., which equates to pragmatic mediation of the object;
– Towards others, namely for creating interpersonal connections, habits of communication, etc., which equates to social mediation;
– Lastly at the subject itself, to reflect its actions, practices, outcomes, etc. which equates to reflective mediations.

The implementation of these functional requirements called for open, modular and loosely coupled technical design which, it was decided, would be pursued with the semantic web technology and the service-oriented architecture (SOA). The project carried out state-of-the-art studies on existing software, comparing functional and technical requirements with various groups of collaborative learning and working environments, such as knowledge-building environments (FLE, Knowledge Forum, CMap Tools), web collaboration environments (BSCW, Google Apps, ZoHo), collaboration and learning environments (SAKAI), and on-line classroom and eLearning platforms (Moodle, Claronline). Although the various environments provided similar features and functionalities to those the KP-Lab project targeted, none of them provided a solid software base to build on. Major prohibiting factors were that the software was not open or the architecture did not support extension of the functionality as required by the KP-Lab pedagogical scenarios.

KPE comes close to many existing virtual learning environments but aims at providing affordances for systematic and sustained creation and formation of collaborative practices and knowledge. The Knowledge Forum has inspired the development of KPE because it provides a knowledge space with functionalities like: to create, link and build on shared multimedia objects. Another system, FLE3, was developed for progressive inquiry practices (Muukkonen, Hakkarainen & Lakkala, 1999; Leinonen, Kligyte, Toikkanen, Pietarila & Dean, 2003). It includes tools supporting virtual inquiry discourse as well as the sharing, co-construction and versioning of digital artefacts. KPE aims to provide support for other aspects than epistemic mediation, or discussion and argumentation (such as: Coler and Belvedere; cf. Coler and Belvedere: Suthers & Hundhausen, 2003). It supports collaborative knowledge creation by offering flexible tools instead of pre-set tasks (see for stricter step-like guidelines such sites as WISE and Viten), roles, or order of executing the tasks. It also provides a holistic and more integrated perspective on the work in contrast to environments which separate processes and different aspects of work more clearly (such as LAMS and Sky Lab).

KPE is also meant to provide a different approach to accessibility from environments connected to typical learning management systems (LMSs) do (note that here we refer to LMS and not generally to virtual learning environments). LMSs are used by universities to facilitate the management of courses and information sharing. An LMS often dictates that the access is restricted to a particular course, so that no one else can see the materials, tasks, etc., except the course/group/team members, and it is hard to add participants from other organizations. The students are tied to the tools provided by the institution, and often using material beyond course boundaries is impossible. Most of the virtual learning environments allow change in the defaults, which however are not easily changed, such as Moodle where the differences in the teacher, group and student roles are very marked. Combining the web 2.0 tool provides personal and collaborative tool ecologies (see, e.g., Arenas, 2008; Crosslin, 2010; Huijser & Sankey, 2010). These combinations include such tools as file sharing systems such as DropBox, combined social media tools including Facebook, Google sites and applications, Zoho, ad hoc tools such as Piratepad, Typewith.me, Zotero, and Confluence wiki, which however is commercial, just to mention few well–known ones. For example, files are often just shared through DropBox or the more advanced SugarSync. Being able to share and keep the versions smoothly synchronized is a start for collaborative elaboration of a shared knowledge artefact, but the tools do not provide further affordances for systematic and sustained creation and formation of collaborative practices and knowledge – all, however emphasize in some respect issues within epistemic mediation (Wallace, 1999; Cigognini, Pettenati & Edirisingha, 2010; Downes, 2005 & Bates, 2010: 24).

KPE is based on a visuo-spatial desktop metaphor that enables working with knowledge items, and the presentation and managing of relations as well as the filtering and organisation of materials and ideas according to meaning, process, or division of work. It also promotes reflection on the spot because of its affordances support object-bound usage facilities. KPE further provides opportunities to integrate different tools so that the information and content flows between tools and services become visible.

FEATURES IN KPE TO PROVIDE AFFORDANCES FOR COLLABORATIVE KNOWLEDGE CREATION

In this section, we describe the Knowledge Practices Environment (KPE) in more detail. KPE users are able to build collaboration environments by creating and configuring the means of the common practice, as opposed to operating with predefined structures. KPE is a virtual environment that includes a set of basic, integrated tools (e.g., working spaces with real-time and history-based awareness, wiki, note editor, commenting, chat, semantic tagging, linking, process organisation, filtering and search) for working with the shared knowledge artefacts. KPE is based on strong visual and spatial ways of organising the work, building on a kind of a desktop metaphor. The spaces do not have folder structures, but KPE supports filtering, spatial organisation, structural and semantic tagging for organizing, restricting or grouping various knowledge items. This approach provides a novel perspective on relations between knowledge and practices as will be described below. KPE enables object-bound and threaded comment on all items (task items, files, web-links, notes) in a shared space as well as viewing of knowledge artefacts and their relations from several perspectives. The three basic perspectives provided are the Content, Process and Community Views. Various tools and functionalities are integrated in the basic views to enable multifunctional and flexible connection, organisation and reflection on all information related to the knowledge artefacts, processes and people concerned. Some screen shots that are presented to exemplify the software have been picked from real course settings (hence some parts of the images may be smudged to protect students privacy).

Work with Knowledge Artefacts (Epistemic Mediation)

Epistemic mediation is supported in KPE by functionalities that enable users to create, modify, build on and organise various knowledge artefacts as well as their relations flexibly. Some important characteristics related to the work with knowledge artefacts are briefly described below.

Sharing and co-construction of knowledge artefacts with free visual arrangement and linking In KPE, user groups can create 'shared spaces' through which various knowledge artefacts can be shared and co-constructed. The basic features include uploading any type of file or web-link into the shared spaces, but instead of providing only a space to store or manage versions and the synchronisation of a vast number of documents, KPE enables the users to organize knowledge artefacts (represented by graphical icons) through visual representations. A central view in KPE for working on knowledge artefacts is the Content View that allows free visual arrangement and linking of its content (see Figure 4.1). The organisation of a shared space reminds the organisation of files on the desktop, except that KPE allows better tools for spatial arrangement and linking of items, filtering based on metadata and tags and the creation of user-defined views ('Tailored Views'). These features and functionalities also allow reflection on the artefacts, their relations and organisation. KPE is not based on folder structures or hierarchical presentation of the content; it does not conceal the content in folders which detach items from their relations. One of the most interesting ideas in KPE is this strong approach to integrating visual and spatial organisation, filtering, categorising, prioritising, semantic meaning creation and process visualisations.

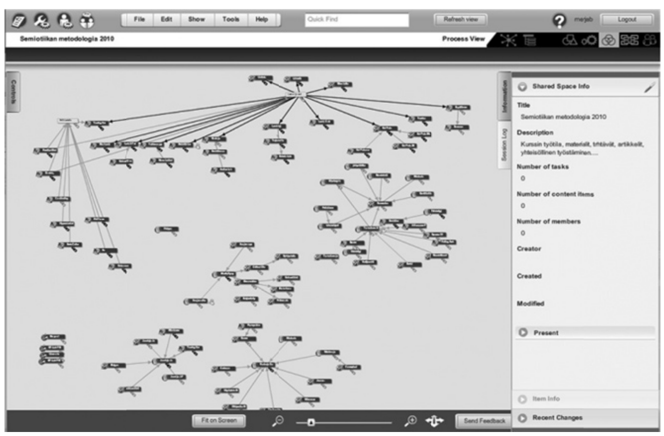

Figure 4.1. Content View: visual arrangement of content items; up-loadable files, Internet links, notes and chats.

In addition to the opportunity to upload files in a Content View, some tools are built in or integrated into KPE to support easy production of texts and sketches as well as co-editing of text versions. With *note editor,* users can directly write their ideas and thoughts as content items in a shared space, without the labour of creating and uploading an external text file (Furnadziev et al., 2009). All members of a space can open and edit the notes and view their previous versions. Furthermore, users can open many notes simultaneously for comparison and integration, and link notes to other content items in the Content View (see Figure 4.2). The implementation of note editor in KPE is a simple, powerful tool for collaborative knowledge creation, drawing on ideas in Knowledge Forum and knowledge-building (Scardamalia & Bereiter, 1994), where one proceeds through idea generation and elaboration using textual notes. Creating, editing and sketching of texts and images in a shared space is an important function since it enables quick access to previous thoughts and arrangements of ideas and knowledge, which is needed to further develop and ponder on the joint procedures, goals and achievements. The Content View includes a *sketch pad* tool which is based on the same idea as note editor, but enables the creation, co-editing and versioning of simple drawings and visual sketches.

The ability to write collaboratively in a sustained manner, an essential feature of knowledge work, is supported through an integrated wiki. A wiki document can be created as a content item in the Content View, which offers the opportunity to access the same wiki document from a shared space. The progress and changes made to the document are visible to all group members. However, history and changes made in the wiki are visible in the wiki but not in the Content View. This makes the writing process in the wiki more independent of other activities in the shared space. The actual use (observed over four years and in six different courses) showed that the wiki was usually taken to be for more thoughtful writing and for producing more finished texts. The students intuitively used the combination of the tools (meaning here without guidance). The note editor was used for idea generation, sketching and drafting. After the sketching and drafting phase were over and the subject matter was felt to be better understood, the students moved on writing in the wiki, where the goal was to polish and structure previous writings.

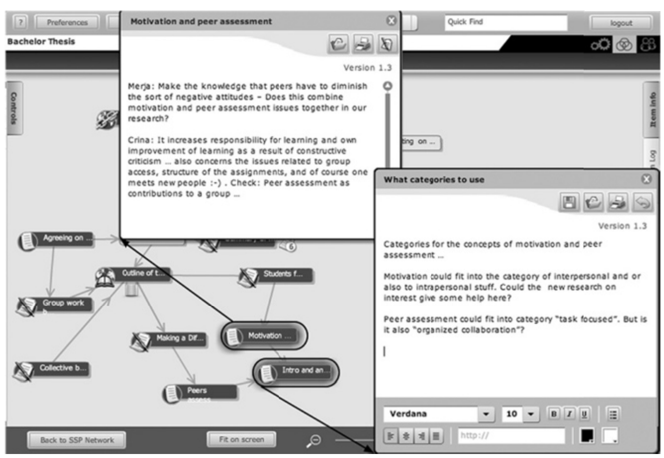

Figure 4.2. Content View: display of the note editor with two notes opened simultaneously.

Object-bound Interaction Around Knowledge Artefacts

In the Content View, "object-oriented" collaboration is emphasized by the object-bound commenting functionality (see Figure 4.3), which means that asynchronous, threaded discussions are attached directly to knowledge artefacts. One object can have many comment threads, enabling users to discuss various aspects of the objects directly in this context. This object-oriented aspect places KPE beyond isolated discussion forums, threaded notes and argumentative discussion supports, which concentrate only on dialogical aspects of collaboration with threaded discussions and easily lose the context and the object. The KPE answers the need to have individual contributions attached in collaborative work organised around shared knowledge artefacts embedded and embodied in a shared space. Similarly, object-bound chat enables synchronous interchange attached directly on the items at hand. The chat log is saved and linked to the targeted item, thus keeping the log attached to its object for possible re-use and continuation. The object-bound features and functions are further supported by the visual metaphor in keeping everything in sight, allowing different spatial arrangements that can be flexibly changed according to the various phases of the work. The items can also be filtered, thus creating yet another visual view of the content. No other tool so clearly allows contextualised work, which keeps all objects visible and allows their filtering after the phase of work is done. The products and processes do not disappear and get lost in folders, sub-pages, tabs or separate forums.

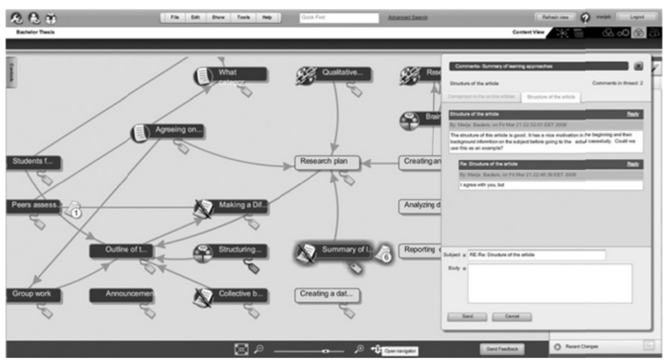

Figure 4.3. Content View: an object-bound comment opened from the selected content item.

Flexible use of tags

One aspect of KPE related to epistemic mediation that goes beyond current learning environments, especially combinations of social media tools and tool economies, is the use of metadata and semantic features to support the usage and integration of knowledge artefacts in various ways. Tags, tag clouds and tag vocabularies can be created and edited by participants. All items can be tagged in the Content View, which provides additional affordances for various types of knowledge practices in education as compared to existing tools. For example, in typical research seminars, semantic tagging can be used to help students find common areas of interest and related materials, or to analyse the elements and concepts of existing research papers and those that are worked on. The tag cloud generated automatically from the tags assigned by users enables easy filtering of the items according to the subject matter, categories, and other user defined taxonomies. In addition, the tags users define are implemented in the underlying technology in a way that allows search through the semantics or relations between tags; e.g., semantic information can be reused across various integrated tools. Such functionalities allow the users to create their own cognitive and conceptual tools and instruments based on the potentialities of the semantic web. Filtering using the tag cloud also allows emphasis on different knowledge artefacts and practices depending on what issues or phases the group or individual is working through. This supports the use of the same Content View for longer periods, enabling sustained work, reuse of items and the reflection of previous work and practices without separating the phases or distributing the items across tools and time. The KPE thus integrates different tools but also allows the use of learning objects, i.e., it supports the SCROM packaging. However, supporting the learning object has not been found to be very useful; rather, the need to provide opportunities, to extend the tools used by API's has been requested from the field.

Organising Processes (Pragmatic Mediation)

Pragmatic mediation has been central to the design of the functionalities of KPE for planning, monitoring, and regulating joint activities and working processes. These functionalities enable users to define tasks as well as draft visual, spatial and semantic representations of processes. They also provide users with 'awareness features' (see below) of the activities in the spaces.

Process Planning Through Defining Tasks and Drafting Visuo-spatial and Semantic Process Representations

In addition to content items, KPE users can explicitly define, modify and arrange *task items* and *areas* to represent the process and domain elements of activities. Task items may include, title descriptors, responsible users, start and end dates and status. Areas attached to semantic meanings can be created to represent a phase, an action, or a category, depending on how the users need to organise their knowledge artefacts. These features allow users to explicate their process elements and promote responsibility and ownership over the decisions and actions.

Task items can be created and modified in the *Process View*, which shows them in the form of a GANTT chart (see Figure 4.4). The Process view enables users to plan tasks and processes chronologically as well as to monitor how the required tasks and subtasks have been accomplished. For instance, in courses that teach collaborative design practices, where real design projects are executed, it is very important (for flexible adjustment of the process) that participants be able to monitor the progress of the project and modify the tasks.

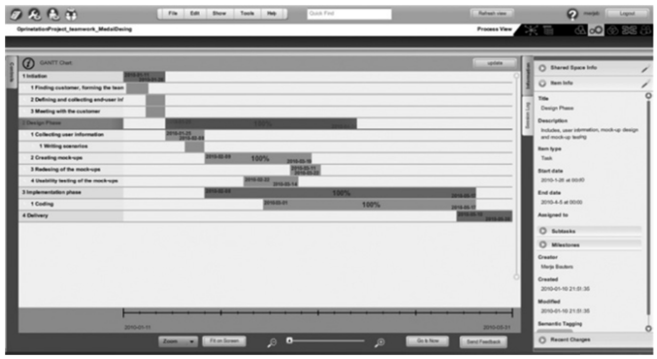

Figure 4.4. Process View: chronological view on the tasks on a time line. Subtasks are the lighter and the main tasks are darker

The same tasks that are displayed in the Process View through a GANTT chart are visible in the Content View, where they can also be created, linked and arranged visuo-spatially manner with the content items. This provides users a holistic and integrated view of their knowledge creation processes, without separating tasks from content (see Figure 4.5). Again, interdependences and mutual connections between the tasks defined in the Process View are automatically converted by the system into graphical constructions representing these connections in the Content View.

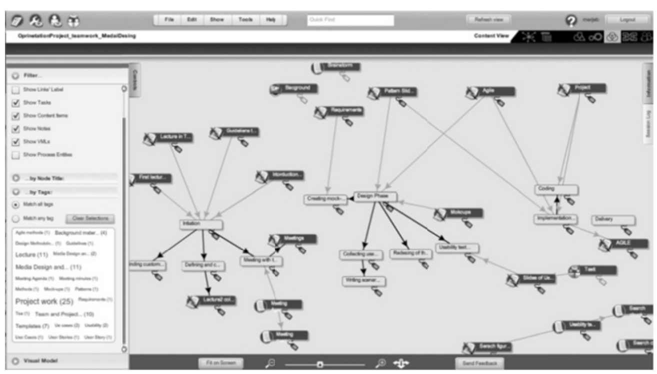

Figure 4.5. Content View of the same tasks displayed in Gantt view in figure 4.4, displayed with all the other items. The left side tab filtering allows displaying, only the tasks, content items, or hiding the links.

In addition, each space in KPE has an *Alternative Process View,* which offers means of structuring the process and its elements visuo-spatially by the users (as an alternative to the linear timeline provided by the GANTT chart). This includes the spatial representation of user-defined areas for organising knowledge artefacts and processes, and enables users to illustrate processes, phases, groups and categories according to shape, colour and place of the areas in question. It emphases relationships between task and content items and their meaning, since the areas can be tagged, and the tags are inherited by all items placed into the particular area. The tags are also presented in the Content View in the tag cloud, from which users can filter the items according to the meaning of the area specified in the Alternative Process View. The figure (4.6a) present the 'Kanban' table of the tasks, issues to be done and the status the items are in. The left tab's tag cloud has same tags as the Content View, it presents how the tags of the areas can be used for filtering (see Figures 4.6b).

Figure 4.6a. Alternative Process View (APV): a student team shared space from a project course where lean programming methods were used.

This feature makes the tagging process easier than it is with most other tools using tags (e.g., Google mail, Diigo, Delicious). It lowers the threshold for using tags and thinking of the meanings knowledge artefacts and their relations have. This is important since experience has shown that it is often a challenge for students to see the benefits of laboriously explicating the semantic meaning and relations of knowledge artefacts. The features of the Alternative Process View are especially useful in those educational settings where the chronology of the work is not essential, but there is a requirement to see connections, associations and causal relations between the various elements of the process (especially if a specific pedagogical model with particular elements is used to structure the process).

Features for focused work on particular knowledge artefacts and tasks The management of knowledge creation processes is further supported in KPE by the use of Tailored Views, into which the users can transfer selected parts of the process (tasks and content items, links, etc.) from the Content View to work within a particular theme or phase of the process in a focused. Tailored View provides another visual means of organising knowledge creation processes by enabling users to arrange shared knowledge artefacts according to a background image or visual structure that presents the various parts of the process (e.g., particular phases in a pedagogical approach). Tailored View supports processes in which a particular topic requires more detailed focus without the abundance of all the material (e.g., inquiry-type practices –

see Figure 4.7) or where particular phases need to be conducted separately in order to be able to move to the next phase (e.g., project-based practices).

Figure 4.6b. Content View related to Alternative Process View in figure 4.6a. Right image: filtered items using one tag ('Backlog').

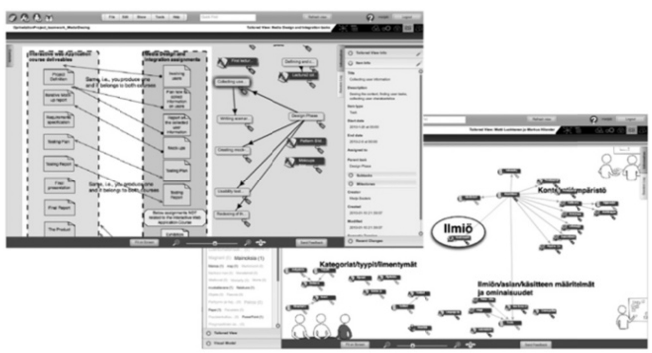

Figure 4.7. Tailored View (layer on top of the Content View): the right displays relations between courses that are held in the same shared space, and the left side is organized by semantic themes and inquiry questions in the semiotic methodology course.

Awareness features to aid process planning and coordination The planning and coordination of a collaborative working process, be it asynchronous or synchronous, will greatly benefit from awareness features that help in explicating tacit knowledge related to one's own or others working practices. Awareness features are not often consciously noticed or paid attention to; however, they may play an essential role in tool-mediated collaboration, keeping track of on-going and past actions. Without such information, the work may be severely hindered. Awareness features in KPE that are meant to support synchronous work include visual clues and on-line notifications about who is online, who is working with whom, or who is working on what object (a lock or a glove is displayed on the item with the names of the users) and doing what. The right hand tab displays all the recent changes in the Content View because no item has been selected. When selecting an item, the recent changes shows what has been executed on that item (see Figure 4.8). Historical perspective is provided by a list about modifications of knowledge artefacts and tasks or by e-mail or mobile device notifications about the events being shared. As mentioned above in relation to epistemic mediation, KPE offers the means to keep in contact with each other, such as asynchronous commenting possibilities, or general chat and object-bound chat to enable synchronous discussions. Awareness features include clues and notifications of participants' status. All these tools are meant to support the planning and organization of on-going activities in an integrated way, not merely from each participant's private perspective, the latter being the main way we have observed in current virtual learning environments.

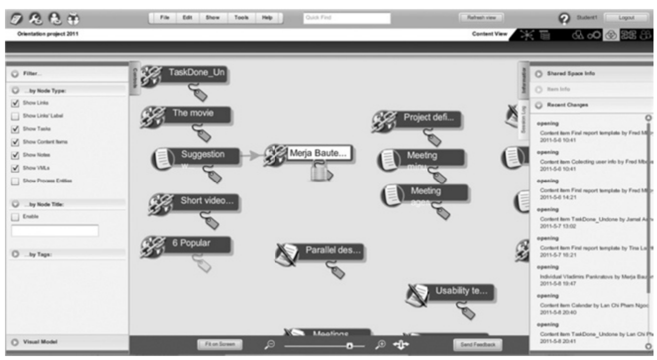

Figure 4.8. Content View: in the middle is a notice that a person ('Merja') is working on the item with a lock on it. No one else can modify this item at the same time.

Social Relations Around Shared Objects and Processes (Social Mediation)

In the KPE, social mediation is implemented by functionalities that support users in presenting group structures and keeping up with changing information about other participants as well as their relations to the shared processes and content items. Social mediation provided by the tools allows users to align their actions with those of others.

Organising social structures, responsibilities and roles

For smooth coordination of collaborative work, it is crucial to explicitly define social structures among the participants, such as groupings, responsibilities and roles. To begin with, it is possible to define people responsible for each content or task item visible in the Content or Process Views. In addition, a third basic view of KPE, called the *Community View* (see Figure 4.9 & 4.10), is especially meant to support the formation of groups (e.g., by displaying the groups/teams formed with the visual information on the users, and their roles, the same members can have more than one role) as well as coordination of tasks and responsibilities between participants. The users are presented as items in the Community View but they are also presented as a list in the Network View on the right hand tab. Both forms of display also show the information on the users' online status. Detailed user information includes a list of all tasks and knowledge artefacts that have been created and modified by or assigned to a particular member. The awareness features mentioned above include clues and notifications of each user's status as well as past and present activities.

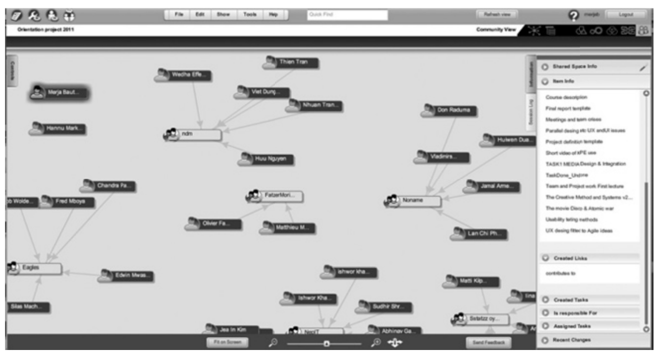

Figure 4.9. Community View: the groups of a project course, the right tab showing items created by a selected user in this shared space.

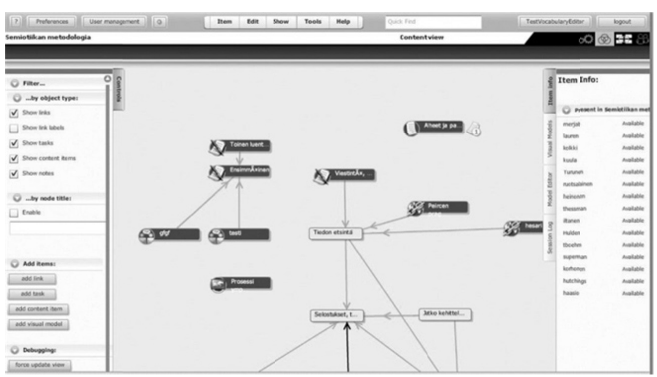

Figure 4.10. Content View: information about online users shown in the panel to the right.

Reflecting on Processes for Deliberate Transformation of Knowledge Practices (Reflective Mediation)

The last of the four types of mediation enables actors to reflect on and evaluate their joint activities as well as the shared objects being created and modified collaboratively. The aim is to provide user groups with information that allows them to take the community's knowledge creation processes as an explicit object of shared reflective activity and consequently elicit deliberate transformation and improvement of their joint knowledge practices. The reflection is afforded in KPE in many ways by the above-mentioned and additional functionalities, e.g., visual representations, awareness tools or analytical services.

Reflecting on the on-going Processes Through Visual Representations and Awareness Tools

One virtue of the visual representations of content items (and related processes) is that they provide users with an overall, graphically supported overview of the current state of the shared space for critical evaluation of the process. In addition, the various awareness functionalities, mentioned above enable users to keep track of the progress of the process and perceive what is going on with the shared objects and tasks, see what the others are up to, as well as acquire off-line information about events and on-going activities.

Reflection and Analysis of Processes Through Analytical Services

Various analytical services in KPE will provide users with an opportunity to reflect on the process from a historical perspective. One means to monitor what is going on within the working environment and to reflect on the community's practices is the *analytic tools* (for more detail see Richter et al., this volume). Especially for researchers and teachers, KPE provides functionalities for exporting available data from a knowledge repository, covering all changes made in the selected part of the knowledge practices environment for a specified period of time (*data export tool*) and use external data analysis tools to evaluate the data. Analytic tools facilitate teachers, students and researchers in analysing information and identifying patterns from collaborative activities conducted around shared knowledge artefacts. Analytic tools also include such applications as *visual analyzer* and *timeline based analyzer*, which process data from user action logs according to the query parameters selected by a user and convert processed data into concise texts, tables and visualizations. These representations allow users to monitor and reflect on their collaborative work, including the contributions of individual members on separate content items and other forms of participation, and the intensiveness of the work on various content items during the time period selected.

EXPERIENCES OF KPE USE IN EDUCATIONAL SETTINGS

As part of the research in the KP-Lab project, successive releases of KPE were used and investigated in several higher education courses applying project work, an inquiry approach or similar knowledge creation practices. This section reviews and discusses some experiences from the field tests conducted in Finland (Jalonen et al., 2011; Vassileva et al., 2011). KPE was tested at the Helsinki Metropolia University of Applied Sciences, in various application design courses for engineering students and in one cross-curricular course between media engineering, industrial management and communications. In those courses, students designed all kinds of multimedia, web and mobile products in teams for real customers, and shared their design documents and tasks through KPE. At the University of Helsinki, KPE was used in several iterations of two methodological courses, one in semiotics and the other in behavioural sciences, as well as in a virtual project work course built up as a multidisciplinary setup involving technical, business and psychology students from three universities: the Helsinki University of Technology, the Helsinki School of Economics and the University of Helsinki, Department of Psychology. In these courses, mainly inquiry-type working methods were applied. In the multidisciplinary course, there was an external client organization for which the students produced their inquiry results.

Benefits Experienced and Strengths of KPE

Many students in the courses reported that the main benefit of KPE was the user interface with space-like views, affording flexible management of knowledge resources in comparison to the typical folder-based environments. This visuo-spatial desktop metaphor appears to be one of the most important and successful elements of KPE. A powerful and unique extension of this metaphor is the easy manner of tagging knowledge resources in the Alternative Process View: areas can be assigned by keywords and all items dragged onto a certain area will inherit the tags of that area.

KPE was found to afford integrated epistemic and pragmatic mediation in particular by, enabling the organisation of various documents and other items into functional clusters, commenting on individual documents and tasks, and the easy creation and flexible modification of textual artefacts for brainstorming or for coordinating joint activities. For instance, the spatial Content View allowed student teams to visually organise their subtasks as well as explicate the sequential order and interdependences between different versions of diverse intermediate documents. Link items were frequently used in explicating multiple connections between various types of resources. This visual representation of relationships between multiple items was considered better than the folder structuring in Google Docs or DropBox, for example. One student from the project work course stated that KPE appears to support an open-ended working process, allowing users to initiate new unforeseen branches to work on.

The integrated note editor was widely used in various epistemic and pragmatic activities of student teams as a flexible and easy to use tool, for such tasks as quick brainstorming or writing coordination plans. In some courses, students created artefacts for work coordination with the note editor to divide tasks and responsibilities within the teams during various phases of their joint work. For instance, a team that had used KPE during the virtual project work course explained in the final interview that the collaborative drafting of notes in preparing the final presentation helped them to integrate all ideas together and then split the whole task into subtasks for each member to work on. In other courses, many student groups also mentioned that an iterative writing procedure of this kind and a clear indication of the state of the text was helpful. Students felt that the drafting phase of the writing process was easier this way, and the actual writing of an essay, report or deliverable was more comfortable.

The actual emphasis in the design of KPE was not so much on social interaction and networking, features supporting social mediation becoming useful when integrated with epistemic and pragmatic support. For instance, in the multidisciplinary application design course, an active team used the object-bound chat in discussing and commenting on their document tasks; they considered it as an advantage that commenting and discussions could be attached to particular items. This allows users to focus their discussions on the objects of their work, unlike other systems where usually only one isolated discussion board is available. Chat was also considered helpful because it enabled discussions to take place synchronously.

The analytic tools, designed as specific tools for supporting reflective mediation, were implemented in KPE quite late, which is why there have been few opportunities so for to test their usefulness in pedagogical practices (Richter et al., this volume). In one course, instructors used both the visual analyzer and the timeline based analyzer to assess the KPE activities of student team as well as the engagement of individual students in their teams' activities. The instructors emphasized the potential of analytic tools to enable the following of activities related to specific documents.

Weaknesses Experienced and Suggestions for Improving KPE

The negative aspect of KPE most often mentioned was its overwhelming number of features and functionalities, which made the tool complex. This is important feedback since it may restrict and even entirely prohibit the use of KPE. Therefore, reducing the least used functions, or the functions and tools that have already been designed and are in use by other open source communities and are available on the Internet, has been planned. The reduction of functionalities is intended to keep the threshold of beginning to use the tool as low as possible. The Tailored View was one of the features which was originally meant for filtering items for more detailed and concentrated work on some selected objects. The field experiences showed that it was too complex a solution for the users. The most useful new feature that Tailored View provided was the opportunity to include a background image on the virtual desktop. The same opportunity was later implemented in the Alternative Process View, which also otherwise provides better means than the Tailored View for process planning as well as for organizing and filtering shared knowledge artefacts. In the future, integrating the Alternative Process View with the Content View and reducing overlapping features and functionalities is a relevant option for developing KPE.

Student teams in the courses investigated appropriated the use of KPE to varying degrees, and only some teams sense the unique potential for effective knowledge creation activities and its added value. This outcome relates to the feedback on the complexity of the tool. There are so many good and simple tools on the Internet to be used for collaborative activities that if we want KPE to be adopted and appropriated, the whole user interface and user interaction logic has to be simplified. For instance, many open source editing tools (e.g., editors built on the Etherbad engine such as piratepad.net or typewith.me) offer chats and timelines that are tied to the writing itself. These chats are also object-bound similarly to the object-bound chat in KPE. These tools are extremely easy to use, respond fast, and often do not require signing in. One of the future improvements of KPE will thus be to open it up for user-generated ‘add-ons’ and linking of other open source tools into it better based on the users’ ad hoc needs.

The facilitation of contextualized, object-bound user interaction seems to promote quick brainstorming and collaborative production of ideas when both synchronous and asynchronous communication modes are supported. The original aim in implementing both possibilities was to provide flexible tools that allow users to lean on each other’s competence, expertise and experience and help them align their actions with those of others. KPE both makes explicit and visualises the participants’ activities in the virtual spaces (see Figures 4.8–4.10), which seems to help students become more conscious of the challenges and more systematic with the strategies of collaborative knowledge work. However, the ability to connect the work within KPE with existing users’ networks, or to post notifications from KPE to other social media platforms and the other way round are highly desirable extensions to KPE design.

CONCLUSION

In the end, summarising the experiences and results of the scientific research of five years, it can be concluded that KPE captures the essence of the trialogical perspective, that is, offers means for working with shared objects and processes from multiple perspectives and in an integrated way.

- It allows commenting, collaboration and organising and sharing of work in a holistic and visuo-spatial manner, stressing the process besides the outcomes. The KPE desktop metaphor provides multiple perspectives on the knowledge artefacts and practices.
- It supports the reflection of practices in context, not separating activities into fragmented reflection parts. The KPE’s object-bound interaction enhances opportunities for reflecting on individual and collaborative products and practices.
- It enables flexible group formation.

- It supports information display of online statuses, social relations, roles information, etc., and use as well as multiple perspectives on the work by various filtering methods (e.g., with tags, visuo-spatial organisation, linking, etc.).

KPE was found to support virtual project management and the practical organisation of collaborative processes, but also open, joint development of ideas. The management of collaborative and/or sustained knowledge creation processes in a flexible, multimediational way is one obvious strength. KPE also served the mediation of epistemic, object-oriented activities by providing a space for collecting resources and organising successive iterations of materials and items, as well as by the commenting facility. KPE appears especially to support the early phases of the knowledge creation process and the integration of different activities (separate, specialized tools are usually needed for actually working with different types of content). In addition, in the courses examined, KPE provided awareness of synchronous and asynchronous knowledge creation processes by showing the contributions of participants, hence supporting the elaboration of items. The ability to get visual overviews of things, to organise processes flexibly and visuo-spatially and to tag items through placing them in particular areas are especially appreciated features of KPE (related to a "virtual desktop" metaphor).
However, there are challenges that need to be taken into account and met in developing KPE further. Such challenges include the following:

- KPE is too complex and needs serious reduction of features and functionalities. Such integration forms as SCORM – packages in particular were found to be useless. Furthermore, it seems that both the learning objects and semantic metadata (which is based on ontologies) are losing ground to microdata, also called microformats. These formats try to provide an alternative solution to the RDF construction that was based on ontologies and has clearly failed in this attempt.[3]
- KPE is competing with other tools, which users already know and which are continuously emerging on the Internet. These tools are easy to use and do not require registration. KPE needs to be opened up so that these tools can be added and used in collaboration with it.
- The previous point relates to the requirement of integrating individual self-reflections with group activities and offering awareness information about the social system in which individual activities are embedded. New distributed social tools and services (e.g., pushing feeds for the group, mashing and filtering group feeds that enable people to interact in the group environment from within personal learning environments, would help to provide scaffolding both for an individual learning process and for collaborative activities.

NOTES

[1] This paper is an elaborated and updated version of a paper presented at the CSCL'09 conference (Lakkala et al.: 'Main functionalities of the Knowledge Practices Environment (KPE) affording knowledge creation practices in education')

[2] Knowledge artefacts are products which are created, developed or used by individuals, groups of people or the learning community, where both their conceptual or epistemic aspects (they embed knowledge) and material qualities (they are some sort of entity with certain material characteristics) are emphasized. Typical examples of knowledge artefacts are documents, models, graphs, visualizations, notes, etc.

[3] schema.org

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5. A PRAGMATIC APPROACH TO COLLABORATIVE SEMANTIC MODELLING: THE VISUAL MODELLING (LANGUAGE) EDITOR

INTRODUCTION

Conceptual modelling has attracted a lot of research interest in recent years and various tools, such as Cmap[1], Compendium[2], FreeStyler[3], and Belvedere[4] have been developed to support the collaborative creation and work with various kinds of visual models. This interest is hardly surprising, given the prominent role of conceptual modelling across a large variety of professional and educational domains. As physical or digital artefacts, conceptual models provide important means for the explication, communication, and scrutinizing of each other's ideas and concepts. In order to guide the modelling process and to support mutual understanding among participants, semi-formal notations or modelling languages are used regularly both in professional, training as well as educational settings.

Recent research in the Learning Sciences provides important insights into the utility of conceptual modelling for learning, and current tools allow creating and working with these models more effectively (cf. Allert, Markkanen & Richter, 2006; Beguin, 2003; Suthers, Vatrapu, Medina, Joseph & Dwyer, 2007). Nevertheless, we believe that, in order to unfold its full potential for learning and knowledge creation, we have to reconsider *models* as *epistemic artefacts* in the sense of investigative instruments and provide users with tools which not only allow them to create their own models but also put them in control of the semantics, i.e. the modelling languages, these models are build on. While predefined modelling languages provide scaffolds and can help to create common understanding, they might also impede collaboration and knowledge creation when they force users to stick to given perspectives and distract them from the issues and phenomena they are working on. Recent advances in semantic web technology provide new and more powerful means to support collaborative modelling (Braun, Schmidt & Walter, 2007; Domingue, 1998; Gangemi Presutti, Catenacci, Lehmann & Nissim, 2007; Morita, Izumi, Fukuta & Yamaguchi, 2006; Sereno, Buckingham Shum, Motta, 2007) but, so far, respective applications have been overly complex to use and hardly in line with the pragmatic requirements of knowledge workers and students (cf. Hepp, 2007; Froehner, Nickles

A. Moen, A. I. Mørch, S. Paavola (Eds.), Collaborative Knowledge Creation: Practices, Tools, Concepts, 75–92.

& Weiss, 2004; Van Kleek et al., 2008). Towards that end, a high knowledge barrier, requiring substantial background knowledge to use the tools efficiently, an overemphasis on ontological considerations detached from other knowledge processes, combined with the use of static schemata as well as the enforcement of explicit and complete specifications beyond users' interest, appear to be the predominant problems that hamper the utilization of these technologies.

The KP-Lab Visual Modelling (Language) Editor (VM(L)E) provides a flexible and easy to use collaborative environment for creation, use and evolution of conceptual models and their underlying languages in diverse domains of interest. The VM(L)E draws on the recent ideas for a pragmatic semantic web (McCool, 2005; Schoop, de Moor & Dietz, 2006) and considers modelling as an inherently epistemic activity that goes beyond the mere representation of what is already known and what can be agreed upon. The vision behind VM(L)E is to provide users with possibilities to create their own conceptual tools and thereby to advance pre-existing perspectives. In contrast to other tools, such as the Distributed Visual Language Environment, which require users to select a (self-defined) language beforehand (Hoppe, Gaßner, Mühlenbrock & Tewissen, 2000), the VM(L)E allows users to modify the underlying language throughout the modelling process.

Building on a brief introduction to its theoretical and empirical foundations, we outline the core motivating scenarios and high-level requirements underlying the design of VM(L)E. Against this background, design decisions and implementation is detailed and insights from field trials are reported.

COLLABORATIVE MODELLING – KNOWLEDGE PRACTICE & TOOL SUPPORT

Despite the significant interest in collaborative modelling for learning and knowledge building, it appears that research and development in computer-supported collaborative learning has been focused on the utilization of conceptual modelling (e.g. in the form of concept or argument mapping) for instructional purposes, while less attention has been paid to modelling as a means for knowledge creation. In the current discussion on conceptual modelling for learning, models are usually conceptualized as means for the explication and communication of knowledge, while the respective modelling languages provide methodological or instructional tools to foster and scaffold the modelling process. Models are thereby first and foremost characterized by their capability to represent a target system such as a certain phenomenon, a set of data, a theory, a domain of discourse or a product, in order to communicate, explain, or predict those phenomena of interest (cf. Frigg & Hartmann, 2006). Even though this approach appears to be appropriate when aiming to support the explication and communication of knowledge and *'to express the group's emerging consensus'* (Suthers et al., 2007), it undermines the epistemological value of models in that it restricts them to representations of what is already known.

Adopting a knowledge creation perspective on learning (cf. Paavola & Hakkarainen, 2005; Paavola, Engeström & Hakkarainen, this volume), and building on the work of Knuuttila and Voutilainen (2003) and Knuuttila (2005) we understand creation and manipulation of models as a genuinely epistemic activity that goes beyond the representation of a target system for communication purposes but aims to produce new insights and ideas. Drawing on the work of Morrison and Morgan (1999), Knuuttila argues that scientific models can be understood as *'investigative instruments'* or '*productive things*' which are partially independent of both the domain theory (or formal domain knowledge) and the world. Accordingly, a main purpose for the use of models is not to represent what is already known but, on the contrary, to come to terms with what is not yet known.

Conceptualizing models as epistemic artefacts, as proposed by Knuuttila (2005), has far reaching consequences for the understanding of models as well as modelling practices. First, models as manifestations of human agency are purposively created artefacts and not as an end in itself. Hence modelling should not be treated as an isolated activity but as an integral part of more overarching knowledge practices, such as scientific inquiry or product development for example. Second, models have, besides their conceptual, a material form and, therefore, are subject to the affordances and constraints of the medium used for modelling. These affordances and constraints are due to the technical as well as conceptual tools used for modelling. Modelling languages, here in the sense of conceptual tools, are crucial towards this end as they entail ontological commitments and make some aspects of domain more salient than others (e.g. Suthers, 2001). While fixed modelling languages are helpful to scaffold the modelling process and to establish a common understanding among participants, they easily become problematic from a knowledge creation perspective when they limit expressiveness or force participant to predefined perspectives. Third, models might become knowledge objects in their own right, and their creation and manipulation can result in new knowledge or even constitute new realities. The productive nature of models becomes especially apparent in such domains as health and engineering. Here, models are not just used to abstractly represent a target system but to actively design or intervene in the target system. For example, the reorganization of a business unit along newly-defined workflow models or the adoption of a new diagnostic scheme in a hospital reach beyond the realm of abstract representation but inherently affect the target systems they are supposed to model and have a direct bearing on reality.

Re-conceptualizing models as epistemic rather than as representational artefacts also poses new requirements for tools in support of collaborative modelling. The creation and use of models and their underlying languages should be as integrated as possible. Instead of treating modelling as a separate activity, collaborative modelling should be tightly integrated into the groups' work processes, allowing for easy access and reference to other resources used. Towards that end, tools for collaborative modelling should be an integral part of a respective learning and working environment. Rather than restricting users to a predefined set of modelling languages, they should be able to modify existing or create new languages whenever needed. To allow for an integrated work on models and modelling languages, users have to be able to move easily between both levels of abstraction without mixing them up. Furthermore, learners should be assisted in developing alternative models and support for triangulation of different perspectives; these models can be based on the same or different modelling languages. Supporting long-term and boundary-crossing processes of knowledge creation affords reuse, and evolution of the employed models and languages. Towards this end, users have to be aware of existing models and languages, to understand their specific purposes but also to adapt them to their local circumstances and own ideas. Allowing users to create and maintain their own modelling languages also requires powerful metaphors and easy-to-use tools to overcome the formalization barrier imposed by current tools. As concepts and their interrelations often become apparent, and crystallize only over a series of consecutive refinements and applications, learners should be supported in the systematic development and enrichment of models and their underlying languages. In order to trace the rationale of their evolution, means for comparing successive versions of models and languages have to be in place. Furthermore, whenever feasible, feedback should be provided to learners regarding possible consequences that a suggested change will have.

THE VISUAL MODELLING (LANGUAGE) EDITOR

The Visual Modelling (Language) Editor is part of the Knowledge Practices Environment, developed in the Knowledge-Practice Laboratory project (www.kp-lab.org). The Knowledge Practices Environment is a web-based collaborative environment offering various facilities for individuals and groups to interact with knowledge artefacts, knowledge process models as well as other users. The Knowledge Practices Environment aims at supporting students as well as practitioners in their working and learning activities. The environment provides users with flexible means to create, annotate, work on, and modify shared artefacts as well as to organize them visually (Bauters et al., this volume; Markkanen, Holi, Benmergui, Bauters & Richter, 2008).

The Visual Modelling (Language) Editor provides an extension to the basic functionalities offered by the Knowledge Practices Environment and allows users to create, share, use, and update visual models as well as the underlying visual modelling languages as another type of shared artefacts. The aim of the Visual Modelling (Language) Editor is to provide users with an easy-to-use and customizable yet semantically powerful tool for collaborative modelling in diverse domains of interest. Exemplary application scenarios include, but are not limited to, the collaborative analysis and advancement of social practices, the modelling of problems, requirements, and options in design projects as well as the explication and analysis of logic models for evaluation and strategy development. In all these cases modelling is conceived as part of a more overarching activity whereby the model is meant to be an epistemic artefact for knowledge creation.

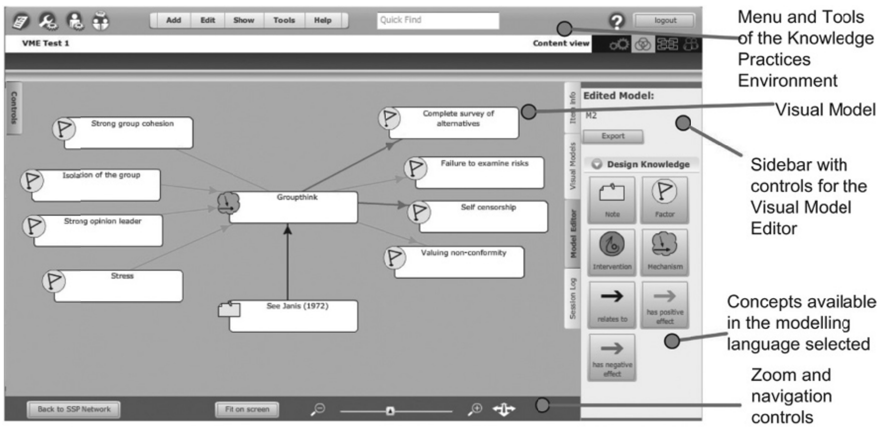

Figure 5.1. Graphical user interface of the Visual Model Editor.

The Visual Model Editor comprises two core components: the Visual Model Editor, which allows users to create, compare and update visual models, and the Visual Modelling Language Editor (VMLE), which provides users with possibility to define and revise underlying visual modelling languages and, hence to specify the semantics of the models. Figures 5.1 and 5.2 depict the graphical user interfaces of the Visual Model Editor and Visual Modelling Language Editor.

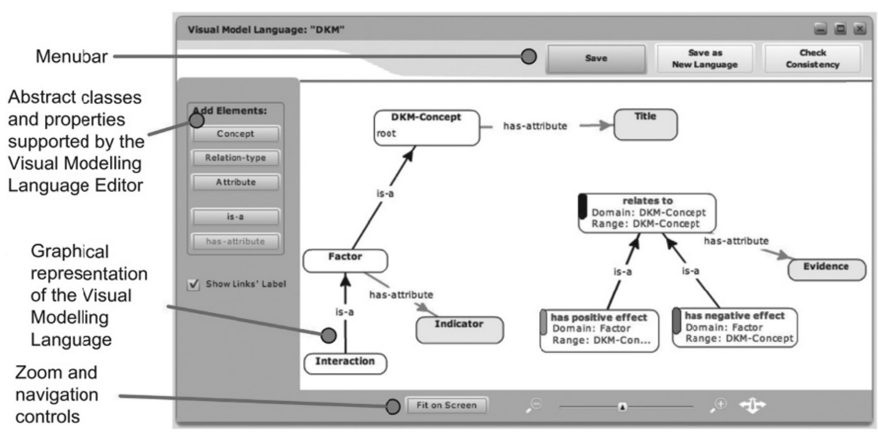

Figure 5. 2. Graphical user interface of the Visual Modelling Language Editor.

The Visual Modelling (Language) Editor allows users to work collaboratively on visual models with explicitly defined semantics. The semantics are accessible to the user by means of the respective visual modelling languages. Providing access to the semantics of visual models and enabling users to revise and update these semantics while working on a particular model allows to create own conceptual tools. It also supports the use of visual models as epistemic artefacts since visual models can carry along the meaning their creators initially attributed to them.

The visual models as well as the visual modelling languages are represented as graphs to the user. While in principle other visual encodings would also be feasible, we decided to use graph-based visualizations, as they provide a very common metaphor familiar to many users and are extensively used in education as well as in professional domains. Furthermore, this type of visualization has a high degree of flexibility and can be easily handled by prevalent interaction techniques. To provide a better overview, even in the case of large-scale models, only the title of nodes and an icon representing the type of concept are displayed permanently. Additional information such as a description and concept specific attributes are displayed upon mouse rollover. Similarly the user can decide whether labels for the edges are to be displayed or not.

As shown in Figure 5.2, the visual modelling languages are depicted as graphs, with nodes symbolizing language concepts, relation types and attributes as well as edges representing is-a and has-attribute relations. The Visual Modelling Language Editor allows users to modify the language tree by adding/removing concepts and relation types (as instances of the metalanguage generic types), changing their attributes and defining constraints on the way concepts can be linked together in the visual models by specifying the properties' domain and range. Each model is based on a particular modelling language and is constructed from the concepts and relation types defined in this language. The metalanguage used to specify the visual modelling languages is based on a review of modelling languages and tools more commonly used in education as well as an analysis of the visual modelling languages that have been created within the KP-Lab project. Based on this analysis, and aiming to provide a tool also suitable for users with limited or no background in conceptual modelling, we decided to keep the metalanguage as simple as possible while being expressive enough to realize a broad array of visual languages used in education. An exception to this is that the Visual Modelling Language Editor allows users to specify attributes not only for concepts but also for relation types. This particular requirement arose from the analysis of the languages developed in KP-Lab project.

Another particular challenge, stemming from the attempt to allow users to work on the models and the underlying modelling languages simultaneously, is to find a proper mechanism to ensure the integrity between models and languages. This is due to the fact that visual models might evolve not only based on direct user-inflicted changes but also because of changes to the underlying modelling languages. Towards this end, various proposals, including the preview of effects on existing models as well as the semi-automatic update of models, have been discussed. In the current version a quite rudimentary solution has been implemented. To ensure consistency between a model and the modelling languages, the type of a node or edge is set to unknown in case the respective element has been deleted from the visual modelling language while the vertex or edge remains in the model. Although the semantics of this node or edge are not defined anymore, the user still has access to the respective information and can decide him- or herself whether to delete the node or edge or change its type according to the modified modelling language. A more advanced mechanism would also provide suggestions to the user, e.g., if there were alternative concepts that are semantically closest to the former one. In any case it appears important that the user stays in control of both the modelling language and the models and can trace the changes resulting from a modification of the language.

To support easy transition between modelling and other collaborative activities, the Visual Modelling (Language) Editor has been directly integrated into the Knowledge Practices Environment. Both visual models and visual modelling languages are represented as icons in the content view (a graphical display of the available artefacts) of the Knowledge Practices Environment and can be handled as any other content item. Once a visual model is opened it is displayed on a translucent layer 'on top' of the content view. Figure 5.4 shows an opened visual model with items on the content view visible in the 'background'. While the visual model elements can be identified as white rectangles with arrows between them, the content items are represented by the darker colour rectangles partly concealed by the model elements. As can also be seen from Figure 5.3, model elements can be directly linked with other artefacts at the group's disposal, hence providing an additional layer to structure shared resources.

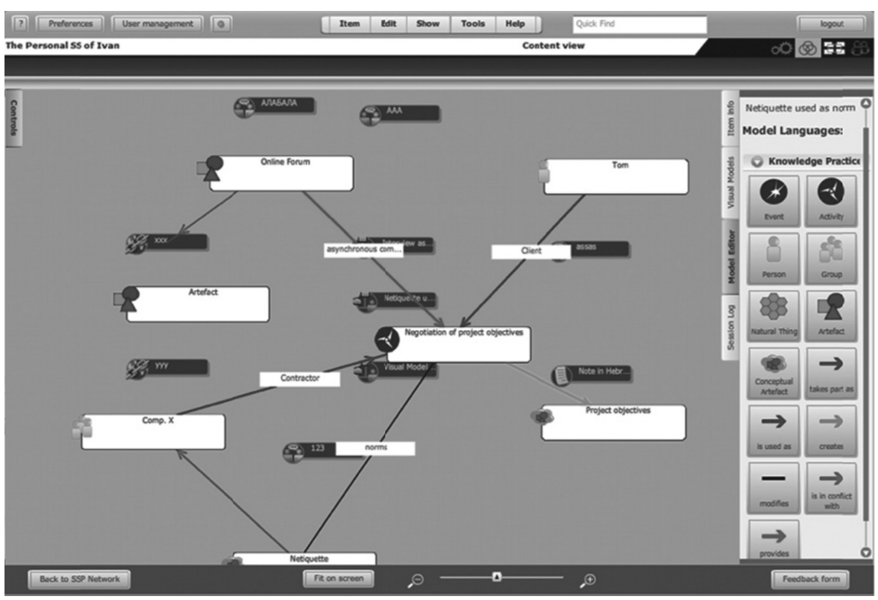

Figure 5.3. A visual model 'in front' of other resources available in the content view.

To support different modes of collaboration, the Visual Modelling (Language) Editor allows for both synchronous and asynchronous work. Therefore, changes are propagated in real time to all members of the group that are online but also logged by the system in order to trace back changes while someone has not been online when a model was modified. Commenting and chat functionalities provide additional support towards that end. Finally, logs and models can be exported in textual format for detailed analysis outside the Knowledge Practices Environment.

ARCHITECTURE AND TECHNICAL IMPLEMENTATION

The Knowledge Practice Environment is a distributed multi-tier web-based software system (Figure 5.4). The KPE front-end is implemented as a Rich Internet Application based on Adobe Flash and running inside a Web browser (a web browser with Adobe Flash support is the only requirement for the client side, making it easy to use the KPE tools in any environment). The Flash client operation is supported by various ‘front-end’ web services, which constitute the middle tier of the web application. The supporting infrastructure for the ‘front-end’ web services (persistence, authentication, authorization, logging) is provided by the ‘KPE Platform’, which consists of several persistent storage spaces (e.g. databases) and web services.

The KPE user interface provides several ‘views’ (content, process, tailored and community views) and various ‘tools’ (note editor, chat, sketch pad, process tool, annotation tool, Visual Model Editor, Visual Modelling Language Editor and others). The tools are used to create content items, tasks and other KPE artefacts. The views provide different perspectives and ways of organizing these artefacts. The content items and other KPE artefacts are stored in repositories, provided by the KPE platform and, thus, are also shared by the rest of the tools in the platform.

In the KPE VML ontologies, the basic ‘concept’ class is a subclass of ContentItem class, form the KPE Trialogical Learning Ontology (TLO) – the core domain ontology used in the Knowledge Practices Environment. Similarly, the basic VML ‘relationship’ class is a subclass of the TLO:Relationship. This coupling with the TLO facilitates the integration of the VM(L)E tools in KPE and provides a unified view on the KPE artefacts. The visual languages, the visual models and their elements are all seen as content items by other tools in the Knowledge Practices Environment. This unification allows for interoperability among the different tools in the KPE; for example, for individual visual model elements to be annotated with the already existing annotation tool (the KPE Annotator) without the need of any external intervention.

At the middle tier, the VM(L)E tools rely on the Collaborative Semantic Modelling (CSM) front-end service for retrieving and storing the visual models and languages in the KPE Knowledge Repository. The translation of the visual model/languages graphs from/to RDF also takes place in the CSM service. The front-end services are implemented as HTTP based RPC-style SOAP services and deployed on Sun Glassfish Application Server. Another aspect of the VM(L)E operation is the collaborative editing, which requires reliable messaging for state synchronization and locking. This is handled by a dedicated synchronization service based on Adobe LiveCycle DS server. The presentation elements of the visual model/language graphs, like identification icons and line styles, are kept in the KPE Content Repository.

At the back-end tier of the KPE architecture, the Semantic Web Knowledge Middleware (SWKM[5]) serves as a gateway to the KPE Knowledge Repository (KR) and provides a suite of advanced knowledge management services that support actions both at the Visual Model and the Visual Modelling Language levels. These services include the ability to query and update the Knowledge Repository. SWKM supports advanced knowledge management functionalities that are superior to most of the existing knowledge management platforms, either generic ones like KAON (Gabel, Sure & Voelker, 2004) and Hozo (Kozaki, Sunagawa, Kitamura & Mizoguchi, 2007) or specific ones targeting the e-learning arena like IMS Abstract Framework (Guangzuo, 2004) and ELF[6]. More on this can be found in Kotzinos, Flouris, Tzitzikas, Andreou, and Christophides (2008).

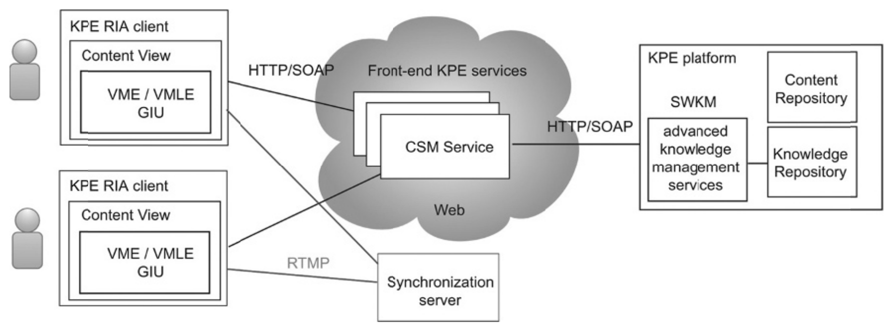

Figure 5.4. KPE / VM(L)E architecture.

FIELD TRIALS AND FINDINGS

Besides dedicated usability tests, the different releases of the Visual Model Editor have been used in several university courses carried out by the University of Helsinki as well as the University of Applied Sciences Upper Austria, throughout the winter-terms 2008/09 and 2009/10. In the following, we briefly describe the pedagogical scenario and findings obtained from the field trials carried out at the University of Applied Sciences Upper Austria in the bachelor programme 'Communication and Knowledge Media' and provide an example of how a teacher has used the Visual Modelling Language Editor to devise a Visual Modelling Language to plan one course at the Christian-Albrechts-Universität zu Kiel.

Students' Use of the Visual Model Editor

The compulsory cornerstone course 'eModeration' is aimed at fostering students' knowledge practices in solving complex design problems. Throughout their first semester students are asked to envision, develop, implement and evaluate a solution for a complex design problem in the fields of eCommunication and eModeration. To promote an inquiry-oriented and reflective design approach from the beginning, students have been asked to constantly explicate their understanding of the design space in the form of a conceptual model.

In the two iterations of this field trial that took place in winter terms 2008/09 and 2009/10, the students were introduced to the Visual Model Editor as well as the visual modelling language devised by the research team in close collaboration with the teacher.

In all, 35 students in 10 project teams took part in the first and 29 students in 9 teams took part in the second field trial. Both field trials lasted for about five months. The groups met face to face with the instructor alternately, every second week. Figure 5.5 shows a screenshot of the sample model created by the instructor to introduce the Visual Model Editor in the first iteration.

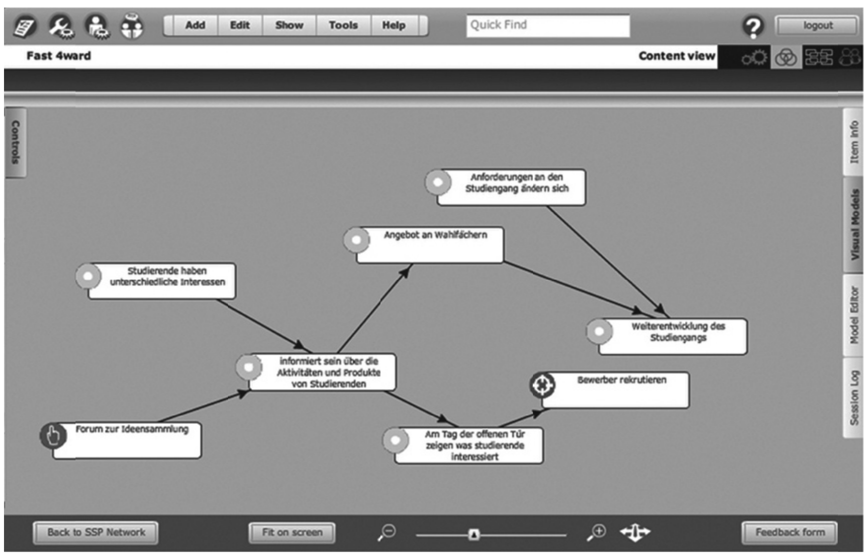

Figure 5.5. Sample model of the instructor.

As part of an accompanying research study, we have been interested in students' appropriation and utilization of the Visual Model Editor while working on a complex design task. The primary aim of the study has been to better understand how students actually make use of the Visual Model Editor and the semantics of the languages provided as well as to inform the further development of the Visual Modelling (Language) Editor. The following observations and findings are based on an exploratory analysis of the models created by the project teams (screenshots had been taken on a weekly basis), the responses to a questionnaire administered to all students at the end of the first iteration, as well as interviews with representatives of four teams in the first and eight teams in the second iteration.

In both iterations the project teams responded quite differently to the modelling assignment, which is reflected in the number of additions and modifications made to the models over time, the overall number of models created and their structure.

While there have been some groups that made only limited use of the Visual Model Editor or abandoned it after some first tryouts, the majority of groups worked on their models fairly systematically. The number of nodes created per group ranged from 18 to 107 in the first and form 9 to 36 in the second iteration.

Even though the Visual Modelling Languages had been introduced carefully to the students and scope notes for the different concepts are easily accessible via the Visual Model Editor, we found that the specified factor, which provided a kind of default concept in the language used in the first iteration, was used quite excessively by all teams (cp. Figure 5.6).

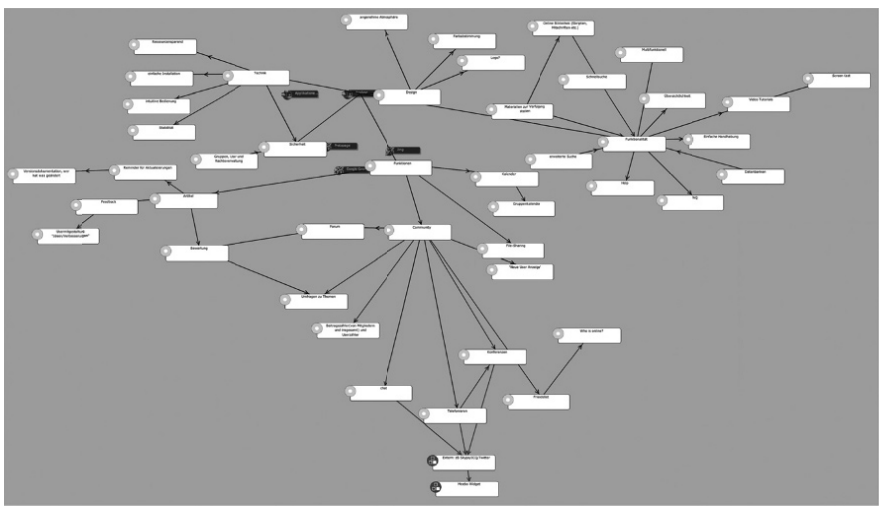

Figure 5.6. A model created in the beginning of a project. Even though the model is already quite complex, hardly any other concept than the specified factor is used.

Those groups who started to work on their models right from the beginning made hardly any use of the more specific concepts provided to depict their design space. This behaviour only changed later, after the instructor provided additional guidance on how the different concepts could be used efficiently. In contrast, two teams that started to work on their models relatively late made more sophisticated use of the different concepts available right from the beginning. This finding is partly in conflict with the expectation that explicitly-defined concepts would scaffold students' elaboration of the design space. It might be that in early phases of the design process effort to explicitly classify ideas according to a predefined scheme does not outweigh expected benefits, or even hinders brainstorming-like collection of ideas. This assessment might change later on when the scope of the project becomes clearer and there is more need to structure and integrate existing ideas. This interpretation is at least partly supported by students' reports on how they created and used the models at different stages of the project. In the second iteration, all teams made use of a broader set of concepts right from the beginning. This might be due to the teacher being more sensitized to this issue, and providing better guidance from the beginning, but also to the fact that the Visual Model Editor was introduced at a later point in the project, where students already had collected information about the design space requiring some kind organization.

Some students in the first iteration mentioned that the predefined modelling language had been too restrictive and that they had difficulties mapping their ideas to the concepts provided. The examination of the models revealed that several teams had problems making proper use of the concepts provided: they mixed up resources and actions and/or, the understanding of the idea of typed nodes – for example, they introduced a concept specified in the Problem Analysis Language as a separate node. We found fewer such problems in the second iteration, providing some indication that the revised modelling language better matched the students' understanding. Besides these perceived limitations, we found at least one case n which a team actively introduced a new concept (the visual modelling Language Editor was not available at that time). In Figure 5.7 it can be seen that the team added a kind of prefix, in this case 'problem', to the title of several nodes to provide an additional 'typification'. These observations parallel those reported by Hoppe, Gaßner, Mühlenbrock and Tewissen (2000), who found that the semantics of the concepts provided could not be taken for granted, but require a constructive explicit effort on the side of the users. The findings also underline the need for a possibility not only to edit the models but also the underlying modelling languages.

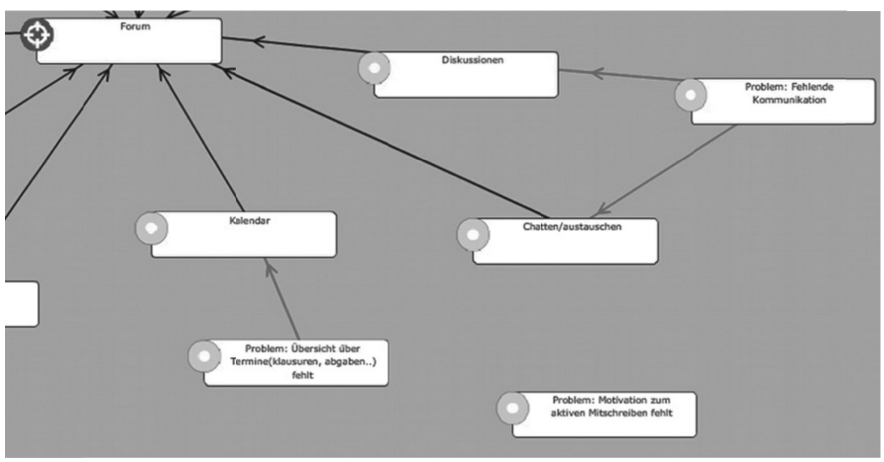

Figure 5.7. Partial screenshot depicting the extension of the modelling language by the prefix 'Problem' to title of the nodes on the bottom and the right side.

The comparison across teams in the first iteration revealed that those who used the Visual Model Editor more intensively often created more than one model in the project's lifetime. While, in some cases, the creation of multiple models was reportedly due to the fact that the current release of the Visual Model Editor does not allow changing the type of a node once it has been created, other groups created multiple models on purpose. Interviews with the students as well as examinations of the models revealed at least the following reasons for working with different models in parallel. One of the interviewee's reported that they had created multiple models in order to be able trace back their understanding at different stages and, hence, to provide some kind of history. In another case, the participants reported that they produced different models to depict different aspects of their project. A third group obviously used different models to elaborate and compare different project ideas, weighing the pros and cons of each proposal. In the second iteration we also found that about half of the teams created a new model in the course of the project rather than revising the existing one. Having a closer look at the conceptual similarity within and across models created by the teams, we found that the overlap coefficients between different versions of the same model have been very high (1.0 for all instances in the first iteration and between 0.91 and 1.0 in the second iteration), indicating that the teams added but did not delete elements. In contrast, overlapping coefficients across models created by a team were significantly lower, rarely reaching values above 0.5, indicating more significant changes in the contents of the models. One possible interpretation for the creation of multiple yet rather unrelated models is that students understood visual models as a means for documentation in the first place rather than as a cognitive tool in support of collaborative inquiry.

Finally, closer inspection of the visual models revealed that in some cases students obviously used the conceptual models not only as an epistemic artefact, depicting the design space, but also as a means to organize their collaborative work. For example, some models included open questions to be answered later on but also as kind of to-do-lists. This finding is also backed up by the students' reports, indicating that in several cases the models were also used to monitor and assess the work progress.

Even though these findings are preliminary, it appears that the adoption and utilization of semantically-rich conceptual models heavily depends on the direct added value for the user. The assessment of required efforts and expected benefits might also change, depending on the stage of the project as well as the actual task at hand. Consequently, tools to support collaborative modelling have to be quite flexible in order to accommodate the changing requirements that arise during the lifecycle of a project but also for the different strategies adopted by a particular group. Furthermore, the findings back up previous observations that the use of visual modelling language is a non-trivial task and that languages have to be designed carefully to provide meaningful scaffolds. Finally, the results point to the complexity of collaborative modelling as a real world practice that might not only fulfil an epistemic but also a social, pragmatic and even reflective purpose.

A Teacher's Use of the Visual Modelling Language Editor

In this section we describe a Visual Modelling Language that has been created by a teacher in order to plan and explicate the rationale behind one of her courses at the Christian-Albrechts-Universität zu Kiel. The teacher had been asked to expose her ideas on an upcoming course in order to attune and focus an accompanying research study. The teacher volunteered to use the Visual Modelling (Language) Editor for this purpose. Both the Visual Modelling Language and the Visual Model have been created during two meetings between the teacher and the researcher involved in planning of the research study. The teacher as well as the researcher had been familiar with visual modelling as well as the visual model editor and had collaborated on other projects before. Nevertheless, the primary aim of the meetings has been to describe the planned course rather than to specify a Visual Modelling Language.

Figure 5.8 shows a screenshot of the Visual Modelling Language Editor displaying the Modelling Language created by the teacher. The language includes eight concepts (ultimate goal, intermediate goal, intervention, outcome, context, input mechanism and wild card) and one relation type (influences).

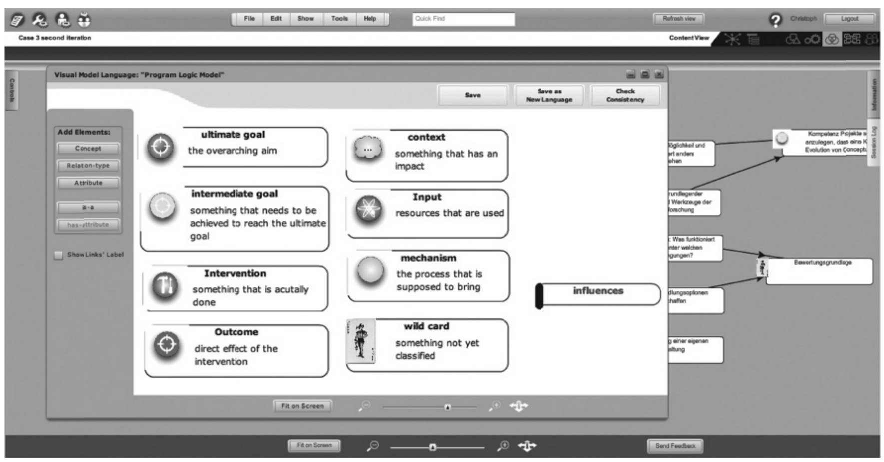

Figure 5.8. Screenshot of the Visual Modelling Language created by the teacher.

Although the language is quite rudimentary, in that it does not specify any particular attributes or is-a relations, it provides the core concepts used to create what has been called logic-models in the field of programme evaluation (cf. Rogers, 2000). The teacher was familiar with logic models from previous works and, hence, the decision to build a respective language appears to be likely. Nevertheless, there are two things that appear to be noteworthy about how she actually implemented the language.

First, she introduced the concept ‘mechanism’ to denote ‘the process that is supposed to bring about a change’. While some authors in the field of programme evaluation, such as Rogers (2000), have made a strong point for the explication of the assumed mechanisms a programme is supposed to trigger, this is an often-neglected logic-modelling practice. Hence, the fact that the teacher deliberately included this concept into the language also means that she takes a certain perspective on logic modelling explicated in the language.

Second, the teacher included a concept called ‘wild card’ to denote ‘something not yet classified’. This concept provides a kind of placeholder and allows the user of the language to add elements to the model which appear somehow relevant to the model but do not yet seem to fit any of the other concepts. In contrast to the other concepts, the 'wild card' has a kind of pragmatic purpose in that it allows the user of the language to suspend decision on the correct classification of any idea immediately but lets them store the information and think about the appropriate classification later on. Even though this approach seem to be at odds with the idea of clearly-defined semantics, it perfectly reflects the fact that, in practice, users often have a hard time seeing immediately where an idea fits into the entire model. It also enhances the understanding that the ability to change the modelling language is highly necessary since, in this way, such practices would be limited or might even disappear.

Figure 5.9 shows a screenshot of the visual model the teacher created based on the language described above.

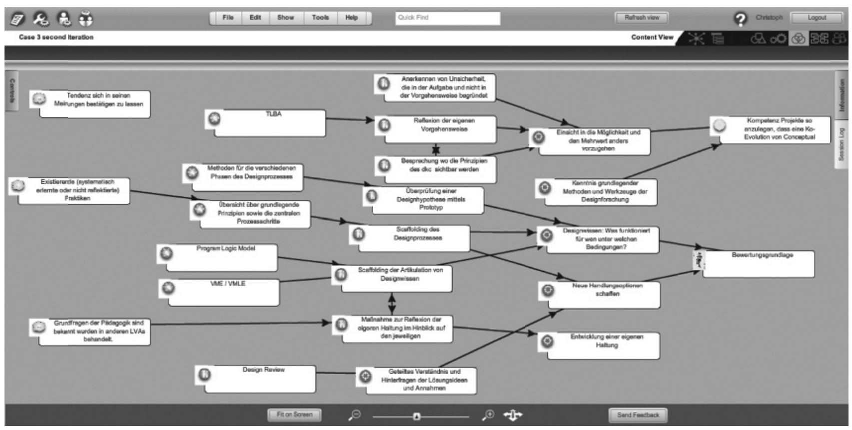

Figure 5.9. Visual Modelling Language created by the teacher to depict rationale for a planned course.

As the teacher has been familiar with visual modelling, as well as the visual modelling editor, it is difficult to make any generalizations from this example. Nevertheless, the example provides some more evidence that the metalanguage employed by the visual modelling language editor is indeed sufficient to specify language of interest for practitioners.

CONCLUSIONS AND FUTURE WORK

Collaborative modelling is a core knowledge practice across a variety of scientific and professional communities. Even though various researchers, instructional designers and developers investigate processes of collaborative modelling and explore new methods and technologies to foster these processes, the understanding of collaborative modelling as a knowledge practice is still in its infancy.

In this chapter we sketched briefly our understanding of modelling as an inherently epistemic activity going beyond the mere representation of what is already known and what can be agreed upon. Against this background we introduced the Visual Modelling (Language) Editor as an attempt to provide users with a flexible and easy-to-use but still semantically-powerful tool for the creation of visual models and their underlying modelling languages. The vision behind this tool is to provide users with the possibility of creating their own conceptual tools and, thereby, to advance pre-existing perspectives. Based on findings from the field trials with the Visual Mode Editor, it appears that the adoption and utilization of semantically-rich conceptual models to a large extent depends on the direct added value for the user, while at the same time modelling fulfils not only epistemic but also social and pragmatic purposes for the user. Additionally, experiments with the Visual Modelling Language Editor support the assumption that the chosen meta-language is suitable to define languages of practical value.

NOTES

[1] http://cmap.ihmc.us/
[2] http://compendium.open.ac.uk
[3] http://www.collide.info
[4] http://belvedere.sourceforge.net
[5] SWKM Website: http://139.91.183.30:9090/SWKM
[6] http://www.elframework.org/

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6. ANALYSING EXPANSIVE LEARNING IN A MULTI-LAYERED DESIGN PROJECT

INTRODUCTION

The learning of design teams has been the focus of academic interest for several decades. From the investigations of intra-team performance, present-day research has proceeded to analyses of distributed teams mediated by advanced technology. As organizations are increasingly networking to accomplish their tasks, design settings also become networked and complex, inviting heterogeneous ensembles of actors to join the process. In this chapter, we will argue that design activities are multi-layered rather than confined within the boundaries of a single team. This is demonstrated in the case of designing a virtual learning tool for workplace development called Activity System Design Tool (ASDT hereafter). The multiple layers are: 1) activity of the ASDT application design team; 2) integration of the ASDT design with design of the generic KP-Lab environment; 3) integration of the ASDT design activity with the partner company's in-house developmental needs; and 4) integration of the ASDT design activity with end users of the learning tool.

Because of the complexity of such research settings, we argue that there is a need for methodological development to gain knowledge of the learning dynamics involved. As shown in this book (see introduction), the trialogical learning approach highlights that collaborative knowledge creation takes place and is best understood through material objects that the participants of a given community are oriented to and co-produce (Hakkarainen & Paavola, 2009). Coupling this principle with expansive learning – learning by expanding the object of activity (Engeström, 1987; Hakkarainen & Paavola, 2009), – we will present an activity-theoretically informed framework (Chaiklin et al., 1999; Engeström, 2008) to analyse learning in a multi-layered design project. The leading idea of this methodological effort is that even micro-level initiatives for expansion of the object of design may indicate learning.

In the context of networks, expansion needs to develop across the layers to signify learning (Toiviainen, 2007). The emerging layers of activity create new boundaries and the need for boundary-crossing between the activities. Boundary-crossing has typically been analysed between separate societal activities that share at least partially the same object, e.g., a patient in the cooperation between special and primary health care (Kerosuo, 2006). The layers represent intermingling activities of a network that pursues a collaborative object of activity, such as designing a digitalized learning environment to serve a variety of needs. The dynamics of layers and boundaries has recently been discussed by Kerosuo and

A. Moen, A. I. Mørch, S. Paavola (Eds.), Collaborative Knowledge Creation: Practices, Tools, Concepts, 93–116.

Toiviainen (2011). We will suggest analytical concepts to study local initiatives across the layers of design activity, concepts which will be applied to discursive data from a design project. Although our emphasis is on the development of analytical methods, our interest in learning in design projects leads us to offer tools for further tests and elaboration in investigations of networked learning.

The questions are:

1) *What does the analysis of the object-oriented multi-layered design work show about expansive learning?*
2) *What kinds of activity-theory-based analytical tools can be developed to analyse learning in multi-layered design discourses?*

To answer the questions, we start the chapter with the notion of the complexity of design work, followed by the concept of expansive, object-oriented learning and its interpretation in "co-configuration work" (Engeström, 1987; 2004). We outline our framework for analysis, and explain our criteria for selecting data from the design discourse before we summarise the stepwise procedure of carrying out empirical analysis in the multi-layered design setting of the ASDT application design. Four design meeting discourses will be analysed, one from each layer of design activity during a short and intense period in May 2007 when the release of the ASDT specifications for the KP-Lab project was the most pressing task. We proceed from development of the methodology to enrich the analytical framework. The concluding discussion will sum up our findings on expansive learning in a multi-layered design job and evaluate the methods of analysis developed.

THE COMPLEXITY OF TOOL DESIGN

From the viewpoint of a project manager, a multi-layered design project is usually presented as a process plan with tasks, milestones, workers, objectives and outcomes. However, many ethnographic studies show that design activity in these projects is complex, socially laden and uncertain (Bucciarelli, 2003; Henderson, 2000; Latour & Woolgar, 1979). No individual has a comprehensive view of the design and the totality of activities at any stage of the process, and efforts to develop a multi-layered approach to design are well-founded. Bucciarelli (2003, 297) defines designing as "the business of a group of individuals, a team." Participant have designated domains reflecting their particular sub-function or subsystem of the design work, and their ways of thinking about the design differ from those of other participants. These domains are called object-worlds (Bucciarelli, 2003). One object of design remains, but there are multiple and different object-worlds, and multiple ways of understanding the object of design. Work within an object-world is usually confined and guided by normative, algorithmic procedures, such as recommended practices for software programming. According to Bucciarelli, however, multi-disciplinary design work cannot be reduced to independently pursued subtasks. Bucciarelli's idea of object-worlds as a different (mental) *understanding* of the object might be interpreted even more literally to mean the material existence of many design objects, which mediate the actions and understanding of the participants during the project. Shifting the focus from the mentally understood to materially created object-worlds in multiple layers requires conceptual elaboration.

In the product design, there is an ongoing discussion about the relevance of the cross-functional integration. How to use diverse knowledge in the organization to produce outcomes that satisfy users or customers and are still affordable for the organization? The discussion is focused on multi-disciplinary interaction that takes place in multi-disciplinary teams and consists of people with diverse expertise. For the purpose of this study setting, we find it more illustrative to use the notion of the design activity that crosses the boundaries of organizations or institutions. We emphasize that the focus of this research shifts away from exploring multi-professional teams (which are relatively stable and are derived from the organization's existing functional structure) to an activity which is dynamic and composed of multiple activities, perspectives and social languages that the stakeholders bring to the design process. In a typical project team, there are members with specific domain expertise requiring some coordination of the project. These may be a project manager, engineers, end users, customers, company managers, and other stakeholders representing different skills and knowledge areas essential to the outcome (Pressman, 2000). In multi-layered project composition, the representation of the participants changes on demand. Considering the heterogeneity and material existence of design objects, we also reject the mentalist prerequisites ascribed to small groups and teams, such as the creation of a collective mind (Carmel & Bird, 1997).

EXPANSIVE LEARNING AND CO-CONFIGURATION

Expansive learning is an activity-theoretical approach that addresses human learning in collective transforming activity systems (Engeström, 1987; Leont'ev, 1978; Vygotsky, 1978). The basic understanding of learning in terms of the expansion of the object of activity acquires new meanings and implications as new forms of activity emerge. The major transformation of the information era has been termed the rise of networks and networking (Castells, 1996; Powell, 1990). One articulation of this major change is the emergence of the co-configuration mode of production (Victor & Boynton, 1998), which has been applied in many activity-theoretical studies (e.g., Engeström, 2004; Virkkunen, 2006; Toiviainen, Kerosuo & Syrjälä, 2009). Engeström (2004, 16–17) characterizes the expansive learning required and generated by co-configuration work as follows: The object of activity is broadened by means of explicitly objectified, designed and articulated novel tools, models, and concepts, forming the visible superstructure of new forms of expansive learning. Learning is a horizontal and dialogical activity through bridging, boundary crossing, "knotworking", negotiation, exchange and trading, directing attention to the structure of situationally constructed social spaces, arenas and encounters for learning. Finally, learning in co-configuration is also subterranean in that new knowledge objects travel in space and time, across various situations and boundaries, which is the invisible, rhizomatic infrastructure of new forms of expansive learning at work.

> All this indicates that we need to trace the objects of expert work as they move in space and time, across various situations and boundaries. History is not made by singular actors in singular situations but in the interlinking of multiple situations and actors accomplished by virtue of the durability and longevity of objects [...] This calls for a conscious expansion of attention beyond the subjects, to include and center on the objects of work and discourse. (Engeström, 2004, 18)

Engeström's interpretation of the expansion of the object of activity through co-configuration offers a proper definition of learning. We will come back to the proposed types of structures in evaluation of the findings in the concluding section.

In a previous activity-theoretical analysis of the same case (the development of the ASDT learning tool), it was argued that the learning of a design team takes place through constant questioning, reopening and redefining of the object. Tensions in collaboration and the object of design emerge as various sources of knowledge and professional practices intertwine (Engeström & Toiviainen, 2011). Here we extend the analysis to look at the object construction at several layers of design activity. It is our expectation that multi-layeredness produces various kinds of tensions over the design objects (cf. Igira & Aanestad, 2009; Murphy & Rodriguez-Manzanares, 2008; Uden, Valderas & Pastor, 2008). In sum, learning by expanding the object of design activity is a tension-laden process split by multi-layered interests that encounter each other in collaborative design. Therefore, whether integration of knowledge is achieved at some level or the design process actually leads to fragmentation is a crucial question with practical consequences for learning and the quality of the design outcome.

The research setting is positioned at the intersection of two dimensions, as depicted schematically in Figure 6.1. The vertical axis represents the learning dimension in terms of the expansion of the object of design. The horizontal axis differentiates the intra-layer actions of design, which refers to a design discourse addressing a given layer and context only. This will be excluded from the analysis. We are interested in collaborative inter-layer design actions that potentially have expanding (vs. non-expanding) effects involving at least two layers of actors (e.g., ASDT designers and the partner company's development personnel). Before enriching this framework with activity-theoretically informed analytical concepts and the steps of analysis, we next outline the case, the design of the ASDT learning tool application in the KP-Lab project.

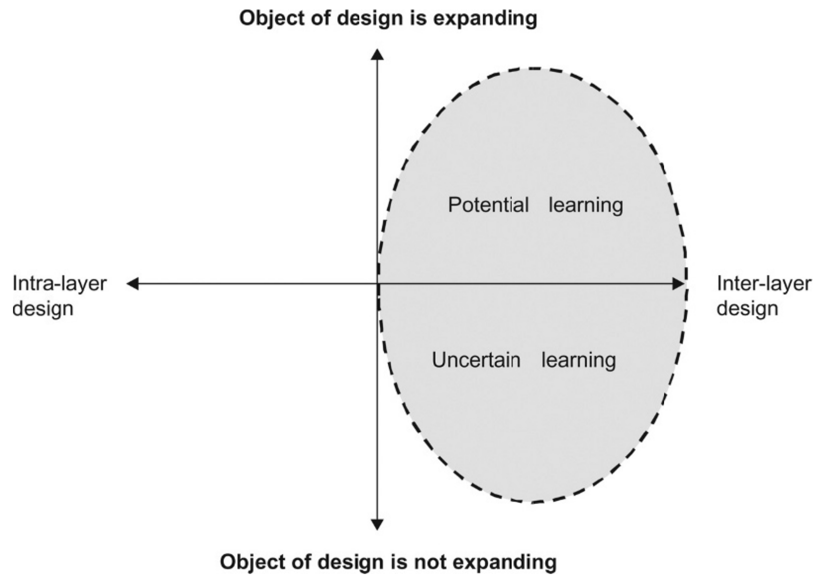

Figure 6.1. Framework and scope of analysis.

CASE: DESIGN OF THE ASDT APPLICATION

The Activity System Design Tool (ASDT) is an application that was designed at the KP-Lab to be linked with the larger Knowledge Practices Environment (KPE). As a tool, ASDT was designed to support "virtual" implementation of the Change Laboratory (CL) method (Figure 6.2). This method aims at enhancing work development, collaborative learning and research through critical analysis of the object of collaboration and by transformation of the knowledge practices of work (Engeström, 2007). To make this happen, the researcher-interventionists and workers bring a selection of "mirror data" from the work activity to the Change Laboratory session. The mirror data is analysed together and solutions are generated by means of the tools and ideas available and created for the purpose. Through the analysis, new models and visions for work are designed and experimented with. The change is also conceptualized temporally by moving across the activity as it appears in the past, present and future perspectives (see the 3×3 whiteboards in Figure 6.2).

The Change Laboratory is based on the cultural-historical activity theory approach and designed to support expansive learning. The development of the ASDT application was included in the KP-Lab project plan with the idea of digitalizing the Change Laboratory tools to be used in dispersed and global work environments. The design was led and coordinated by the design team, including project members from two KP-Lab partner organizations, the University of Helsinki and Pöyry Forest Industry ("the company"). The university-based partner was expected to mediate theoretical and user knowledge of the Change Laboratory method. The company partner contributed to the software design of the Change Laboratory Tools (ASDT) application. In addition, the company's in-house development was supposed to supply contentual case material to test the virtual learning environment (learning of something). These activities were handled by Finnish project partners, which means that data is based on face-to-face meetings leaving out virtual meetings with our other European design partners.

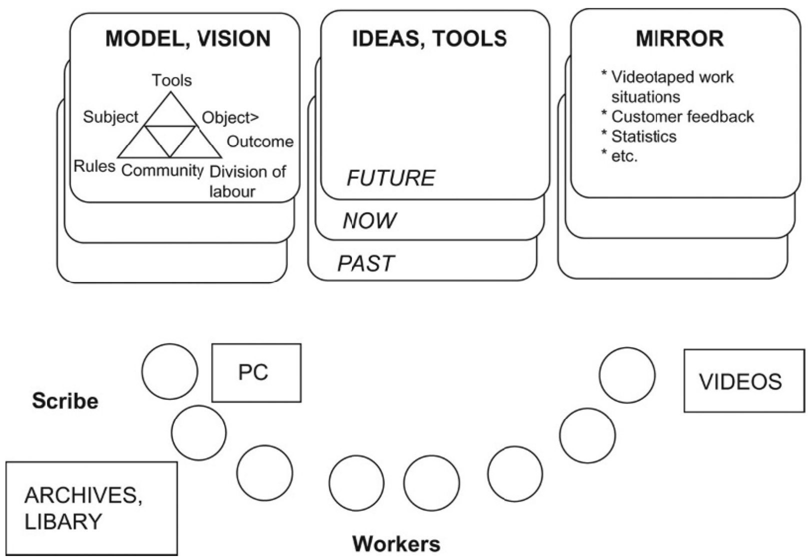

Figure 6.2. Prototypical layout of the Change Laboratory®.

Design work for the ASDT application started in spring 2006. Two main components of the ASDT design task were defined, the digitalization of the Change Laboratory tools and the video annotation application for editing visual mirror material. The design went through several phases in specifying the design task and adapting to evolving organizational changes in the project. The phases were partly overlapping and were named according to the main design object in corresponding phases.

The scenario phase was the initial step of the KP-Lab design to communicate between the project partners how the pedagogical settings utilizing KP-Lab tools would look in the future. One of the scenarios was "Virtual Change Laboratory Tools," which described how the organisation and implementation of the Change Laboratory would be supported and transformed by using the CL Tools later called ASDT (Activity System Design Tool).

The matrix phase was one of the early steps referring to the formulation and cross-tabulation of two design dimensions: what are the main elements of the prototypical Change Laboratory setting and what existing tools and technologies are there to be potentially utilized (Engeström & Toiviainen, 2011).

The mock-up phase produced representations of the basic layout of the Change Laboratory setting, during which it became clear that a specific application is needed, building on existing tools not being enough.

The specifications phase started at the turn of the second project year, 2007, and refers to the approaching project milestone for delivering the technical specifications of all design tasks to the KP-Lab. The interlinking of the ASDT application with the Knowledge Practices Environment (KPE) application became increasingly vital, requiring growing design effort, whereas in the Matrix and the Mock-up phases the internal pedagogical requirements based on the Change Laboratory method dominated.

As such, the phases follow a normal design process. What made it complicated was that designing proceeded on many layers and by different groups of actors. This was because of the KP-Lab design idea of encouraging the technical and pedagogical partners to collaborate with each other and with the participating work organizations and potential users of the ASDT from the early design phases onward. For us as the members of the design team coordinating the process, this was not an easily manageable combination. In the ASDT design, we may discern, first of all, objects embedded in the Change Laboratory approach, such as models of the activity system and expansive learning. Then there are objects to be attuned to the Change Laboratory working environment, such as the multimedia annotation tools, which are also applied in other pedagogical and research contexts of the KP-Lab project. Finally there are objects that link the Activity System Design Tool (ASDT) to the Knowledge Practices Environment (the general platform, KPE) developed at the KP-Lab.

Beyond and in addition to the technical design objects, an actual company developmental object had to be specified as the content of the pilots in which the ASDT was tested and elaborated. We outlined these design tasks as four different forums or layers of design (Figure 6.3). These are:

1. the design of the ASDT application;
2. the design of the generic Knowledge Practices Environment (KPE);
3. the partner company's in-house development activity; and
4. the Change Laboratory (CL) user community.

The last one refers to the researcher-consultants presently applying the CL method in different work-life contexts. Each of these layers will be described.

Layer 1: Design of the ASDT Application

The ASDT design team was founded at the beginning of the KP-Lab project to integrate knowledge represented by various partnering project organizations: the pedagogic-interventionist knowledge of the Change Laboratory method, technological software design knowledge, and knowledge about the company's development interests. The main object was the Activity System Design Tool (ASDT) application to be designed for the Change Laboratory. Its task was also to contribute to the design of the generic Knowledge Practices Environment and other KP-Lab tools, such as video annotation and meeting tools as potentially usable in the CL context. The members were 1–3 university researchers and 3–5 designers and in-house developers from the company (Meeting 1).

Layer 2: Design of the Knowledge Practices Environment (KPE)

From the point of view of the ASDT design, the question is about an extended design team including members from the KPE design done mainly by a Finnish university of applied sciences (Beuters et.al., this volume). The membership varied between meetings, the core being the ASDT designers, 2–4 KPE designers, and some in-house developers from the company. The object of design at this level was the integration of the ASDT application with the KPE (Meeting 3).

Layer 3: The Partner Company's in-house Development

The company had multiple roles in the design process. First, as a KP-Lab partner it was assigned the task of designing the ASDT application. Second, it joined the project with the objective of developing its own learning activity to meet the needs of its global business operations. One of the objects of learning at this level was the implementation of the CRM (Customer Relations Management) system in various forest industry engineering units (Meeting 2).

Layer 4: Change Laboratory User Community

Despite the researchers bringing user knowledge into the design team, a wider user community was needed to evaluate the design outcomes and to start early pilots and experiments with the ASDT application. The user community was organized around the research centre in which the Change Laboratory (CL) method has been developed. The object of collaboration at the meetings with varying set of users was the design document or the design artefact of the ASDT application. The anticipated outcome was the digital application of the Change Laboratory to be implemented at organizational development projects (Meeting 4).

Methodological elaboration is needed to bring these different strands of knowledge creation together in the course of the design process. First of all, we need to make the distinction between the object of design activity that is partially shared by all layers, and the design objects created for the design actions in the interfaces between layers. In activity-theoretical terms, the former represents the motive of collective activity, whereas the latter represents the action-level tasks with specified goals.

The object of design is the virtual application for the Change Laboratory called the ASDT, but what may be seen in the meetings is various kinds of documents as design objects around which collaborative design is organized, such as the "case" material, "mock-ups" and "specs" (specifications) that are not shared by all forums (Figure 6.3).

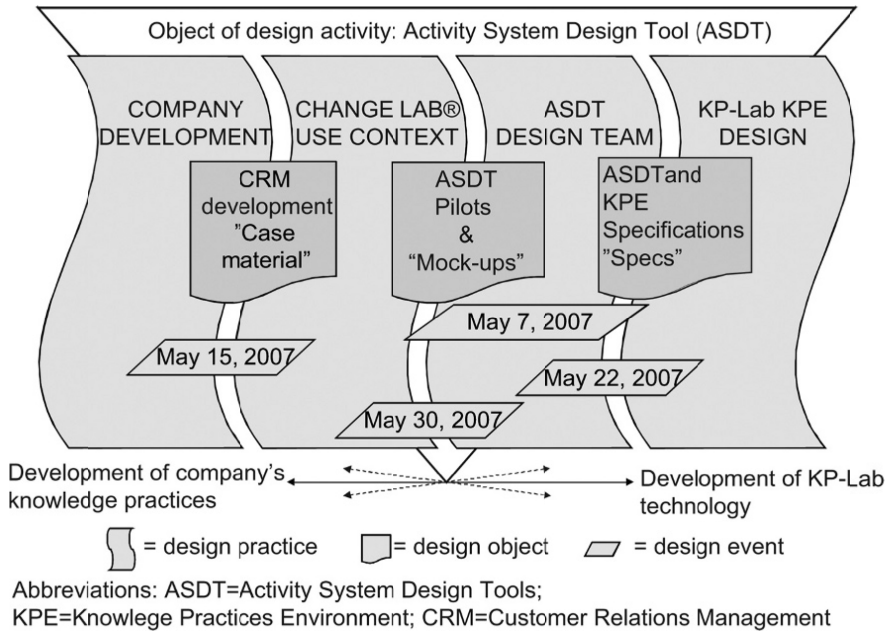

Figure 6.3. Research setting.

METHODS OF ANALYSIS

The empirical data is drawn from design meetings in May 2007, during the specifications phase. We found this an interesting and intense period during which the ASDT design was enhanced at all layers of collaboration. The design meetings; main topics and goals, design objects, and outcomes are summarized in Table 6.1. The analysis of discursive actions addressing the design objects offers a window on the process through which to explore the potentiality of co-configuration and learning. Adopting a critical realist approach to discourse analysis, we assume that design talk constructs the design reality, but not exclusively so, as a strong relativist orientation might suggest. Social realities are also shaped by material conditions and extra-discursive features (e.g., Sims-Schouten, Riley & Willig, 2007). We develop the analytical concept of a design initiative from this frame of reference.

A collaborative design discourse is full of initiatives by which the participants carry out the design task assigned to them. The more complex the task is, the more these initiatives take form of a dilemma (Billig, et al., 1988), which typically involves a choice between two incompatible lines of action. In this data, a dilemma is identified as a design problem to be solved across (at least) two layers of design activity. Another type of initiative in a multi-organizational setting involves boundary-crossing (Kerosuo, 2006), where actors present perspectives and motives to partners and potentially expand the object of activity beyond set boundaries.

Table 6.1. Design meetings analysed

Date 2007, May	*Design Meeting / "Layer" of Design*	*Topic, Goal*	*Design Object*	*Outcome*
7th	ASDT design team	Start writing ASDT specifications document or KP-Lab project	Specifications document, list of contents	First draft of specifications
15th	ASDT design team with Company in-house developers	Negotiate on in-house development (CRM case) combined with ASDT application design	Mirror material from CRM system	Agreeing on the CRM development session to be held on June 12
22nd	ASDT design team with KPE designers	Integrating ASDT specifications with KP-Lab KPE design	Presentation of specifications	Preparing the presentation for the end users' meeting on May 30
30th	ASDT design team with CL / ASDT end users	Getting user feedback to ASDT specifications	Presentation of specifications	Up-dated draft of specifications

Collaboratively discussed, dilemmas and boundary-crossings may both lead to solutions that enhance learning. This happens when the solutions somehow expand the object of design in a co-configurative way beyond the conceptualization held by any one of the layers of design. In contrast, learning will not take place if the design initiatives are rejected or omitted. To grasp this, the concept of rupture is implemented in the analysis. Whereas disturbances are deviations from the observable flow of interaction in the ongoing activity, ruptures are blocks, breaks, or gaps in the intersubjective understanding and flow of information between two or more participants in the activity. Ruptures do not disturb the flow of the work process, although they may often lead to actual disturbances. Ruptures are thus identified by interviewing and observing the participants outside of, or after the performance of work actions (Engeström, 2008, 52).

The analysis of ruptures enables us to explore the communicative breaks potentially counteracting the expansion of the object of design, even though not immediately blocking the continuation of the design process. Ruptures not only encompass intersubjective understanding in the flow of the work process, but may also materialize themselves in the design object. For example, in the analysis that follows, a rupture takes place when a boundary-crossing initiative to re-name the elements of the Change Laboratory setting to better serve the needs of the firm is rejected and not designed into the artefact.

In sum, the design initiatives (dilemmas and boundary-crossings) and their effects (co-configuration or rupture) are the analytical concepts to study learning as the inter-layer expansion of the object of design. These concepts are added to the framework (Figure 6.4).

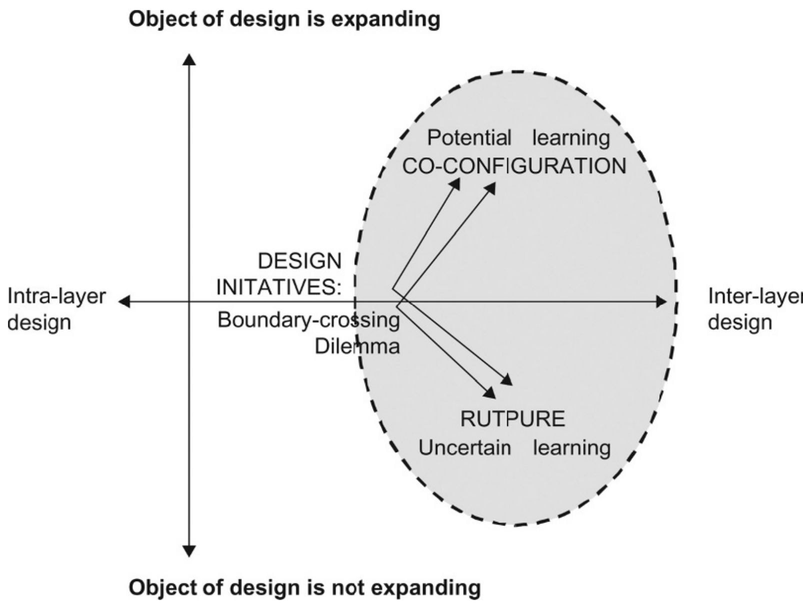

Figure 6.4. Framework and concepts of analysis.

We analysed all four design-meeting discourses at different layers of design applying this framework. Each author of this chapter analysed one or two meetings, before we compared and validated the interpretations reported here. All interpretations had to be based on exact discursive episodes taking place in the flow of discussion. In this chapter, however, we are not going to display all excerpts from the original data. Data excerpts are used selectively, whereas most of the design initiatives and their effects at different layers are briefly described.

The steps of analysis are:

1. Identify the design meeting on the trajectory of design, its aim and goals, the participants, and typical features of the discourse.
2. Analyse the design object presented and discussed.
3. Analyse and separate out the discursive episodes expressing intra-layer development and project talk.
4. Analyse the discursive episodes expressing inter-layer design efforts.

5. Identify and interpret the discursive inter-layer design initiatives (boundary crossings and dilemmas) embedded in the episodes.
6. Analyse and interpret the effects of the boundary crossings and dilemmas observable in the design discourse: will these initiatives lead to (potential) co-configuration (the object of design expands) or will they end in a rupture (the object of design is not expanding)?
7. Summarise the findings (co-configuration and ruptures) across the layers of design and relate them to extra-discursive context.

RESULTS OF ANALYSIS

In the following analysis, each sub-section starts with the account of the meeting and the design object discussed at the meeting. The outcomes of the analysis of the design initiatives (boundary-crossing or dilemma), and corresponding effects (co-configuration or rupture) will then be presented in Tables 6.2–6.5. There are 1–4 initiatives and their effects at each meeting. Since what is displayed here is the summary of the findings, original data excerpts are shown only when essentially demonstrating the findings. Transcription conventions used in the excerpts are: [text in brackets]=clarifying addition or replacing an identifiable name; (…)=the excerpt text has been cut.

Meeting 1: Design Team of ASDT Application (Layer 1)

Meeting 1 was held by the design team to write the specifications document on the ASDT design that was to be delivered to the KP-Lab project. Present were team members from the university and the company. The due date for the document was at the beginning of August, which in the Finnish context means right after the summer holidays. Given the task and approaching deadline, most discussions in this long meeting represented development talk referring in this framework to the intra-layer object-oriented design talk. There was just a little project talk, referring to "non-object-oriented" organizational and administrative formal issues concerning the project. Boundary-crossing talk is identified as something that brings a new cross-layer element or interpretation to the design setting. By contrast, in this context development talk across knowledge of the Change Laboratory method and the software design (specifications) is interpreted as an expected assignment of the design team and not analysed as a cross-layer issue.

The design object was the specifications of the ASDT application. The table of contents for the specifications was given by the KP-Lab project; however, it seemed that there were still many functional details of the Change Laboratory method to be discussed and translated into the language of software design. This internal tension of the design object occurring between the given format and contextual specification characterized the design discourse at the meeting. Discursive boundary crossings and dilemmas took place across all other layers of design, which is demonstrated as follows.

Table 6.2. Design initiatives 1–4 and their effects

Design Initiative	*Effect*
1 Boundary crossing between ASDT design and company development (1) The "Change Laboratory" (CL) process model follows the expansive learning model. The last phase represents "consolidation and dissemination" of new activity. The company's design team member translated this as: "something we agreed on, start to implement and follow-up".	**Co-configuration** The last phase of the CL process model was named "follow-up and consolidation." Moreover, it was not defined as just a step of the process, but as an "after-CL-sessions", a learning space that should maintain the outcomes of the work development achieved through the CL.
2 Boundary crossing between ASDT design and company development (2) "Change Laboratory" should be renamed when implemented in the company – our people do not want to work in a laboratory, a member claimed. Ideas were drawn from CL-based applications by in-house developers and researchers. There was play with words and hints to company concepts, e.g. "Change Mill".	**Rupture** It was decided not to change name in the specifications document, as "Change Laboratory" was known to other project partners. A new name could tie the tool to the company's use, potentially evoking "copyright" problems, but simultaneously make the design more concrete and motivating for the piloting company.
3 Dilemma of designing roles for the virtual CL use context The prototypical "Change Laboratory" includes roles of interventionist, participants, and scribe. How will the scribe's role change when participants access digital whiteboards? Will the interventionist adopt the scribe's role when manipulating digital whiteboards during CL sessions? Will the interventionist role split (leader, scribe, video annotating), due to setting's complexity ? How do screen captures differ from video recorded documentation?	**Rupture** The dynamics of new roles were not put down on the specifications, but the traditional role set-up was maintained.
4 Dilemma of the functionalities shared by ASDT application and Knowledge Practices Environment (KPE) During design and specification of the ASDT, it became increasingly obvious that many of the functions are shared by the KPE application, but the Design Team was unable to assess which.	**Socio-spatial expansion** At the end of the meeting, a participant called a project colleague in the partner organization designing KPE. A joint meeting was scheduled two weeks later (meeting 3). This initiative is socio-spatially expansive, although it does not directly expand the object, and cannot be defined as co-configurative action.

Meeting 2: Integration of the Design with the Partner Company's in-house Development (Layer 3)

Meeting 2 was typically a boundary-crossing event combining the company's developmental needs concerning the Customer Relationships Management (CRM), development of the Change Laboratory method for company use, and 3) development of the ASDT application by KP-Lab. The ASDT design team member prepared a presentation on problems of implementing the digital CRM database in the company. The meeting's convener was the manager of the company's application services unit in charge of database development. Other participants included head of the company's application service unit, three CRM designers from the same unit, head of the product development unit, two developers coordinating KP-Lab activity from the same unit, a representative of local CRM users, two CRM users (administrators) from the marketing section, two software designers working with the ASDT application, quality manager, two education students assisting in data-gathering, one researcher from the ASDT design team (co-author of this paper).

The design object was split between the developmental challenges of Customer Relations Management (CRM) system and Change Laboratory as a method of work development. The relationship between these topics produced dilemmatic talk. Both co-configurative agreements and ruptures regarding how the in-house development and development of the Change Laboratory method should be combined in design work and implemented in the company were observable.

Table 6.3. Design initiatives 5 and 6 and their effects

Design Initiative	*Effect*
5 Dilemma on the number of CL-based development sessions Is one development session on the CRM issues enough if the simultaneous aim by the company is to enhance developmental, Change Laboratory type practices to manage change processes? What does the Change Laboratory mean in the context of the CRM case?	**Co-configuration** It was agreed that problems of implementing the CRM system should not be analysed too narrowly. Long-term development seems to be needed to build developmental practices and secure people's commitment to sustain practices in the company. The CRM development will be followed by several sessions, also as virtual meetings.
6 Dilemma – synchronizing develop-mental efforts; ASDT design and CRM How should the developmental actions on the CRM case and the ASDT application be carried out and synchronized to meet both the company's and KP-Lab's goals ?	**Rupture** It was agreed that development of the virtual environment by KP-Lab will be usable directly and needed by the global company, but what implementation of virtual Change Laboratory actually means in the context of developmental sessions and in the distributed practices of the company, was not discussed.

Meeting 3: Integration of the Design with the Design of the Knowledge Practices Environment (KPE) (Layer 2)

A meeting was held to integrate the ASDT specifications with the Knowledge Practices Environment design. Regarding KPE, the basic functions, including first mock-up representations, were finished. The participants were the ASDT design team members from the university and the company (as in meeting 1), and KPE designers from the project partner organization, the university of applied sciences, who had been familiarized with the ASDT design at previous meetings, but did not specialize in the Change Laboratory approach as such.

There was a lot of intra-layer development talk on the ASDT design and a lot of project talk at the end of the meeting. There were also co-configuration type episodes that are not included in this analysis. These discussed the specialities of the ASDT application in relation to the Knowledge Practices Environment application, such as the ontology issues and technical solutions to link external tools to the system (connected to the second dilemma). However, the discussion remained speculative, as the issues addressed were not topical at the time, and not to be solved in the first release of specifications.

The design object was the specifications of the ASDT application. Discussion was mostly organized around the written ASDT specification material prepared by the ASDT design team at Meeting 1. Interestingly, the intended focus, the integration of ASDT specifications with the KPE application, changed to concern over how the specification document should be represented to intended ASDT users and how to obtain ideas from them at the coming meeting (Meeting 4). This shift in focus took place as the KPE designers saw the somewhat abstract ASDT presentation and learned of the coming users' meeting. Dilemmas and co-configurative solutions arose from this tension and were based on lengthy episodes.

Table 6.4. Design initiatives 7 and 8 and their effects

Design Initiative	*Effect*
7 Dilemma, how to present the ASDT functionalities to the CL users. The major concern expressed by the KPE designers was the level of abstraction of the technical requirements for the ASDT application, as formulated in the specifications document. It would not communicate to the users at the coming week's meeting (meeting 4). The requirements should be offered in pieces to help the users of Change Laboratory explain to the software designers what this means in our practice.	**Co-configuration** The KPE designers suggested showing CL users a lot of pictures and mock-ups, which they had found productive when working in the higher education context. The ASDT application designer accepted by concluding: *(…) when we meet Change Lab people next week and, kind of, present this to them, the more concrete, even if invented by ourselves, the easier it is for them to comment on it. I guess it's exactly the same as you did with your Knowledge Practices Environment mock-up. You tried to depict something and people commented on it. Didn't it go that way?*

8 Dilemma, what external tools should be listed in the specification document and technical solution to link to the Knowledge Practices Environment? This was a technological dilemma raised by the member of the ASDT design team, but the KPE designers again translated it into a communication problem of linking overly demanding tools detached from the user practices, the *wiki* being the case in point. In the design object concerned (ASDT specifications), there was a list of existing tools, which stemmed from the initial Matrix phase (see above).	**Co-configuration** Rather than mentioning existing tools in the specifications, KPE designers recommended starting from example cases, where tools mentioned are used by the case organization and familiar to the users. The ASDT designers agreed and described needs of the forest industry engineering company ("knowledge-intensive work") as an example to give the KPE designers an idea of relatively high technical capability of potential use context of the virtual Change Laboratory. The ready-made list of existing tools (as planned for linking to the application) was removed from the specifications document.

Meeting 4: Integration of the Design with the Change Laboratory User Community (Layer 4)

Meeting with the Change Laboratory users was organized to present the design outcomes of the ASDT application to potential users and to get feedback and ideas. Users were researchers and developers who had undergone the Change Laboratory training. This meeting was organized at the research centre with one of the main developers of the Change Laboratory approach and training, ten users, three assisting education students, and two members of the ASDT design team responsible for the software design and the specifications document.

Roughly a quarter of the time was spent on the designers' slide presentation and the user's intermediate questions and comments, and three quarters on discussion, during which the users were active and the designers mostly listened and asked questions. The users asked for definitions of terms like "semantics", "ontology", and "annotation," and what they might mean in the context of the Change Laboratory (CL). Other comments by the users on the questions presented by the ASDT designers dealt with sequencing phases of the CL process, adding time line, supporting visualization of the models used in CL, aspects important in the CL session planning, and organization of group work in the virtual environment. Long episodes were devoted to the questions of the data management of an individual CL session and the entire process, and the need to move easily across the mirror materials, data produced in the CL sessions, and theoretical models.

Regardless of the recommendation of the KP-Lab designers at meeting 3, the ASDT designers had chosen to organize the discussion around specifications issues instead of showing pictures and mock-ups. As was typical of this meeting, the design object had first to be articulated. One of the users (User 1) and developers of the Change Laboratory method asked for the definition of the "specifications," pointing out that seeing the concept of the Change Laboratory as a design document (instead of seeing it as a pedagogical setting with the "CL whiteboards") was new for the users. This can be seen as a boundary-crossing comment trying to bridge the different representations of Change Laboratory design.

Excerpt

> User1: [NN], could you explain, at least for me it is a strange term “to do specs” [“speksata”]. What is it?
> Designer NN: Well, to do specs, it means that we have to define, that’s what it is. It’s our engineering jargon.
> (…)
> Designer MM: It is a kind of functional plan. We should make up a document on the functions that we are going to implement.
> Designer NN: And after that follows information technological architecture. We cannot, kind of, (can I possibly find the list of contents on my computer). We have written the list of contents [of the specification document] that starts with the definition of the functions of the virtual Change Lab.
> (…)
> User1: This is important in my view. I don’t know how you [the other users] see it, but often when we present the Change Laboratory, we think of representation in terms of what the picture looks like [refers to pedagogical setting of the CL]. So this functionality perspective is probably new to developers of the Change Laboratory, when seen from another perspective.

It turned out that the specification document on the functions alone was not enough motivation for the user group. User 2 took another boundary-crossing initiative concerning different representations of the design object. The absence of the mock-up of the user interface seemed to lead to one of the major ruptures in the object creation at this meeting.

Table 6.5. Design initiative 9 and its effect

Design Initiative	*Effect*
9 Boundary crossing related to design object User 2 suggested that ASDT design would be discussed by means of the visual mock-ups. (..) *By the way, last time you (—) showed us those mock-ups, something about how those whiteboards [of the CL setting] can be used. Did you bring them with you? They are somehow fascinating! [Laugh.]*	**Rupture** Designer NN answered that they had not brought mock-ups with them, as in this phase of the ASDT design it was more important to work on the specifications document. *(…) We left them out on purpose. We thought that when we made that mock-up, we considered the [CL] session as whiteboards. Now that we’ve got to do these specifications – it kind of forced us to go through the whole process.*

The findings of the analysis regarding design meetings 1–4 are summarized in Table 6.6 (see Appendix).

DISCUSSION AND CONCLUSION

This chapter aimed at a methodological development for analysing a multi-layered and heterogeneous design process and its potential for expansive learning. The main empirical data was drawn from the discursive episodes of four design meetings in the process of developing a digital learning tool called ASDT (Activity System Design Tool) as assigned by the KP-Lab project. We will conclude by summarizing and discussing the findings according to the research questions.

Question 1: What does the analysis of the object oriented multi-layered design work show about expansive learning?

We followed the methodological guideline of focusing on the object of design activity. We distinguished between the object of design as the motive for carrying out the multi-layered design, the ASDT application for the Change Laboratory, and the design objects that were worked on at each design meeting.

Object orientation does not mean that the role of the subjects, for instance, the members of the core ASDT design team (layer 1), was marginal. On the contrary, they clearly acted as boundary-spanners (Levina, 2005) across the layers. Neither does it mean that learning in a network would only involve expansion of the object. In this data, another type of expansion was termed a socio-spatial expansion (Engeström, Puonti & Seppänen, 2003) in the transition from the layer 1 to layer 2 (design initiative 4). The point is, however, that the changes in social interaction are detected in association with the participants' actions on the object of design.

The specification document for the ASDT was the dominating representation of the object of design. It was simultaneously a connecting and tension-laden design object across the layers of design. Various design layers gave rise to different inner tensions to be discussed at the meetings, summarized in table 6.6 (column "Design object/Tension"). Each one seems to manifest a tension between the formal, given specifications of the design and the context-specific, use-value[1] type of feature: structured list of contents of the specifications document vs. the specific content of the ASDT application (Meeting 1); short-term problem-solving vs. long-term development of learning practices of the company (Meeting 2); abstractness of the ASDT specifications vs. concreteness of the user perspective (Meeting 3); written functions of ASDT vs. visual representation of the user interface (Meeting 4). The co-configurative actions and ruptures cast more light on the meaning of these tensions and on the learning potential involved in resolving them.

We take it that all co-configurative discursive actions expressed the context-specific and use-value oriented knowledge that expanded the object of design beyond the given specifications (Table 6.6, column "Co-configuration"). The ruptures, however, were regularly associated with, or even produced by, the formal and general requirements stemming from the specifications document (Table 6.6, column "Ruptures"). This overarching notion across all design contexts is critical. It suggests that the interest in participating in the design, making boundary-crossing initiatives and contributing to the co-configuration of the learning tool was motivated by different kinds of use-values envisioned at each layer.

Given the use-value-based orientation, the specifications document as a design object was productive to the degree that it could bond other design objects, such as the CRM development by the company (layer 3) and the ASDT user interface by the Change Laboratory users (layer 4). In the period analysed this was not too obvious. The specifications remained abstract to most of the co-designers, not therefore encouraging boundary crossing and the expansion of the object, the ASDT design, in the best possible way.

These findings may be evaluated by means of the concepts that Engeström (2004) suggested for the analysis of expansive learning in co-configuration work. Firstly, the visible superstructure of the ASDT design and learning by means of explicitly objectified, designed and articulated novel tools, models, and concepts is needed to broaden the object of design. In this case, the specifications document, the mock-ups, the concept of the Change Laboratory, and the developmental challenges of the company were such explicit articulations. As was discussed above, the dominance of the specifications may have not offered the best possible superstructure across the layers of design, each of the design concepts and tools being rather layer-specific. This indicates the difficulty of building visible superstructures and carrying out multi-disciplinary design in hectic project work in spite of deliberate efforts to do so.

Secondly, the structure of situationally constructed social spaces, arenas and encounters for learning are needed to enhance horizontal and dialogical interaction through bridging, boundary crossing, "knotworking", negotiation, exchange and trading (Engeström, 2004). In the case analysed, the meetings can be seen as arenas for learning, gathering designers and users from different contexts of activity to carry out open discussion, development work and problem-solving. Meetings as a form of social interaction are rather conventional. They may be a formal aspect of project administration, but also, as in this case, a forum where the use-values of different layers may be articulated and debated.

Thirdly, an invisible, rhizomatic infrastructure of new forms of expansive learning in multi-layer design work may emerge (Engeström, 2004). It is actually hard to assess how far this kind of subterranean learning is possible in a temporary project job. How do the knowledge objects created travel in space and time, across various situations, boundaries and layers? In the case of the ASDT design, this kind of invisible infrastructure was perhaps provided by the members of the ASDT team (layer 1). They were the boundary-spanners across the layers with whom the design objects travelled from one context to another.

2) What kinds of activity-theory-based analytical tools can be developed to analyse learning in multi-layered design discourses?

We applied the concept of learning by expanding the object of activity to the multi-layered design. The object was studied by analysing discursive design initiatives (boundary-crossing and dilemmas) and their effects (co-configuration and rupture). The analytical concepts are summarized in Figure 6.4.

In order to analyse learning in multi-layered design, we developed the discursive unit of a design initiative. Design initiatives were identified in the flow of the meeting discussion as boundary-crossing or dilemmatic episodes that addressed the object of design and involved two or more layers of the design activity content-wise. Moreover, design initiatives had some effects that could be traced in the same meeting discussion. The effects were either co-configuration like expansive solutions or non-expansive ruptures that nevertheless did not block the continuation of design activity. These effects were discussed above in relation to Question 1.

Adding a multi-layered perspective to the object-orientation made us pay attention to tensions emerging within the object and between different representations of the design objects. As was pointed out in the previous study on this ASDT design case (Engeström & Toiviainen, 2011), there is an obvious risk of technological domination over theory and methodology in the design of learning instrumentalities. Co-configuration, on the other hand, means that all social languages, layers of design and use values involved are integrated into the design process. The analysis of tensions of the design objects may lead to the exploration of domination and biases. This may support the evaluation of the design objects created at different layers.

In the development of the analytical units, we did not find existing models to draw from easily. Klaus Krippendorff (2006) has analysed the transformation of design in the post-industrial era. The history of design problems, the "trajectory of artificiality", has evolved from material products to goods, services, and identities, and further to interfaces, multi-user systems and networks, projects and finally to discourses. This is what he labels "the semantic turn" of design. Krippendorff suggests three analytical perspectives: the meaning of artefacts in use, the meaning of artefacts in language, and meaning in the lives of artefacts.

> (…) artifacts are not merely used but more importantly enter processes of human communication among stakeholders, including users. In language, artifacts are conceptualized, constructed and communicated; their meanings are negotiated and their fate is determined. Such processes can no longer be described or measured in cognitive, ergonomic, and technological terms. They will have to be explained in linguistic terms, in what language makes available to the stakeholders in the artifacts in question. This calls for a dialogic, not a monologic theory of meaning (Krippendorff, 2006, 149).

Krippendorff's presentation is rich with examples, pictures and conceptual categorizations for exploring the meanings of artefacts. The presence of multiple stakeholders, shifting boundaries of design communities and semantic layers of a design are acknowledged. However, what "the semantic turn" fails to offer is analytical tools for identifying design discourses in the language of communities. The illustrations of spoken design artefacts are in fact missing from the book. In our methodological exercise we developed and experimented with some conceptual tools for analysing expansive learning in the multi-layer design discourse. Further development is needed to integrate and intertwine the discursive and artefactual data in the analysis, to move from dialogic to trialogic approach to design activity.

NOTE

[1] Use value is here understood in the Marxian sense as distinct from exchange value. Use value and user value are a specific topic of interest in design research (Boztepe, 2007).

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APPENDIX

Table 6.6. Summary of analysis

Design meeting	*Participants*	*Design object – tension*	*Co-con-figuration*	*Rupture*	*Layers (1–4) involved*
1 ASDT design team	Project members from company and university 6 persons	ASDT specifications -structured list of contents *vs.* specific contents of ASDT application	Making sense of CL process model, relating to process thinking of company		1 ASDT design 3 Company development
				Keep name “CL” instead of inventing new contextual name	1 ASDT design 3 Company development 4 CL use context
				Keeping old CL roles instead of naming new virtual roles	1 ASDT design 4 CL use context
			Socio-spatial expansion of ASDT design		1 ASDT design 2 KPE design
2 ASDT design and company development	Company developers Design team members 15 persons	Development challenges of case CRM – short-term problem-solving *vs.* long-term development of learning practices	Long-term development of business activity and learning environment are needed		1 ASDT design 3 Company development
				Detaching ASDT design from development of company practices	1 ASDT design 3 Company development
3 ASDT design and KP-Lab Knowledge Practices Environment	Project members from both design teams (KPE, ASDT) 9 persons	ASDT specifications – abstractness of design document *vs.* concreteness of user perspectives	Presenting users demos and mock-ups instead of abstract design documents		1 ASDT design 2 KPE design 4 CL use context

			Giving users examples with familiar external tools		1 ASDT design 2 KPE design 4 CL use context
4 ASDT design and Change Laboratory use context	Change Laboratory users Design team members 17 persons	ASDT specifications - definition of functions *vs*. interest in user interface		Excluding visual user interface (mock-up) from specifications presentation	1 ASDT design 4 CL use context

ASDT = Activity System Design Tool;
CL = Change Laboratory;
KPE = Knowledge Practices Environment of KP-Lab.

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7. MIRRORING TOOLS FOR COLLABORATIVE ANALYSIS AND REFLECTION

INTRODUCTION

Analysing and reflecting on one's own and other's working practices is an essential meta-activity for any kind of project work, but also plays a prominent role in the type of object-oriented inquiry and trialogical learning the KP-Lab project is focusing on. Analysis and reflection, therefore, are not understood just as means to optimize or improve a given way of working but also as an active and productive process, geared towards the advancement of knowledge practices. Collaborative reflection thereby exceeds the exchange of individual experiences and insights in that it aims at the development of a shared understanding and transformation of the collective knowledge practice. Depending on the particular context and setting, analysis and reflection might be carried out by a working group itself in collaboration with a supervisor or external expert or by a group of supervisors (e.g. a teacher in collaboration with colleagues).

To support collaborative analysis and reflection, participants need to have some kind of material evidence regarding the pursued knowledge practices. Respective techniques include, for example, narrative methods of storytelling, the writing of diaries and reflection notes, but also log-file-based tools that mirror collaborators' activities in terms of recorded interactions with a shared software application. The exploitation of historic log data holds the promise of providing a great deal of information about group activities without requiring additional efforts for the recording of events by the users. Furthermore, computer-supported systems for the visualization and analysis of process data allow users to search and explore even huge sets of data. While different tools and approaches to support mirroring, mentoring, and guiding collaborative learning have been developed, there is still a need to understand their utility for specific application scenarios (Soller, Martinez, Jermann & Muehlenbrock, 2005).

The goal of our efforts is to provide teams of students, teachers, and knowledge workers with tools and methods enabling them to reflect on their knowledge practices while being engaged in substantial project work over longer periods of time. Emphasizing the productive and open-ended nature of collaborative reflection, our approach is focused on the development of mirroring tools that

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allow users to depict, and interpret the digital traces of their practices in an iterative and collaborative manner. We do not aim to identify useful indicators or patterns of successful collaboration a priori but aim to empower students, teachers, and knowledge workers to identify meaningful indicators and patterns themselves. Furthermore, we consider it important that the analytic tools and methods can be used not only in Knowledge Practices Environment (KPE) (cf. Lakkala et al., this volume) but in connection to any virtual collaborative system that provides respective traces of users' activities. Towards this end, this paper suggests high-level requirements for mirroring tools in support of practice transformation and introduces a set of tools developed in response to these requirements.

Besides its foundation in the trialogical approach to learning (cf. Paavola, Engeström & Hakkarainen, this volume), we draw on research in the areas of Data Mining and Knowledge Discovery, in particular process mining and educational data mining, Computer Supported Collaborative Learning (CSCL) and Information Visualization. In the following we briefly discuss related work in these fields.

Firstly, both process mining and educational data mining can be understood as extensions to classical data mining. While process mining is focused on the extraction of potentially useful information from event logs in general (Van der Aalst et al., 2009), educational data mining is particularly concerned with the exploration of data from educational settings, especially from web-based learning environments (cf. Baker & Yacef, 2009). The use of process data from workplace or educational settings goes along with particular challenges. For example, Perera, Kay, Yacef, Koprinska and Zaiane (2009) pointed out that existing data mining algorithms might be insufficient, given the temporal, noisy, correlated, incomplete, and sometimes small size of the data sets available. Furthermore, it has been argued for information visualization methods in support of human judgment which are appropriate for the users supposed to make sense of the data collected (e.g. Baker, in press). Against this background, this chapter explores requirements for process mining and interactive visualization techniques when applied to poorly understood and loosely-structured data.

Secondly, we build on research in the area of Computer Supported Collaborative Learning, especially those studies that are focused on computer-generated feedback in support of collaborative learning. According to Soller, Martinez, Jerman and Muehlenbrock (2005) respective tools fall roughly into three main categories: (a) *mirroring tools*, which collect, aggregate, and present data about students' interactions; (b) *metacognitive tools*, which mirror students activities but also provide information about a desirable state of interaction; and, finally, (c) *guiding tools*, which provide guidance for remedial action based on an automatic assessment of students interactions. While there has been a growing interest and progress towards metacognitive and guiding tools for collaborative learning, our focus is on mirroring tools, i.e. tools where users instead of the system are in charge of making sense of the data, and relevant events are discovered rather than predefined. Recent proposals for the use of mirroring tools in support of students' reflection on project work have been made, for example, by Kay, Yacef and Reimann (2007) as well as Krogstie (2009). The tools described in this chapter aim to go beyond a predefined and closed set of queries, and to provide group members means to interactively specify indicators and working patterns themselves.

Finally, information visualization is concerned with the visual representation of abstract data to support human cognition (e.g. Card, Mackinlay & Shneiderman, 1999). Aiming to enable users to analyse and make sense of the historic log data, our focus is on interactive information visualization tools supporting exploratory data analysis, i.e. tools that allow users to select data, construct queries, and define mappings from data to visualization views dynamically. Thereby, the general idea is to support the user in developing and probing hypotheses through the iterative creation of successive visualizations. Tools for exploratory data analysis include, for example, VQE (Derthick, Kolojejchick & Roth, 1997), DEVise (Livny et al., 1997), Spotfire (SpotfireHP), or Polaris (Stolte, Tang & Hanrahan, 2002) providing aggregated views on data, as well as the Semantic Spiral Timelines (Gomez-Aguilar, Theron & Garcia-Penalvo, 2009) or Dotted Chart (Song & van der Aalst 2007) for timeline-based analyses. While these tools provide a broad range of visualization formats, there is still a need for intuitive yet powerful mechanisms that allow even infrequent users to specify complex filters and queries and display the results in a meaningful and comprehensible way. The analytic tools described in this paper aim to provide new means towards this end.

To motivate the design of novel mirroring tools, this chapter starts with a brief discussion of the different types of activities and challenges associated with collaborative analysis and reflection on knowledge practices. Against this background we then summarize the main design goals we aim to address and describe the design and implementation of the mirroring tools. Finally, we provide outcomes of first trials carried out with these tools and outline the next steps in the development process.

COLLABORATIVE ANALYSIS AND REFLECTION ON KNOWLEDGE PRACTICES

Collaborative analysis and reflection on knowledge practices can take quite different forms and might involve different categories of stakeholders. In this section we give an overview of the main application scenarios we aim to support, depict relevant epistemic activities in relation to the Trialogical Learning Approach, and pinpoint core challenges for the tools under development.

Main Application Scenarios

Based on a review of previous research cases carried out within KP-Lab and current research plans (cf. KP-Lab, 2010b), three main application scenarios have been identified.

Monitoring Collaborative Activities

Generally, *monitoring* can be understood as the more or less systematic tracking and analysis of activities as they unfold in time. Monitoring activities might be carried out by a supervisor or by the persons directly enrolled in the activity at stake. While monitoring can be used as a means for control, the emphasis in KP-Lab project is on monitoring as a form of technology-supported reflection-in-action. The primary aim in this case is to raise awareness for and to support the analysis of critical events in the course of collaborative action. A prototypical monitoring activity entails the following phases: (a) a triggering event, such as an unexpected incident, curiosity about an intervention's effects or general interest in the progress of work; (b) collection and representation of information about related activities; (c) analysis of the information in light of the question at stake; and (d) decision on remedial actions, if any. Typical instances include a teacher or project-leader who wants to know whether a team faces certain delays, or a group member who wants to check whether fellow members have read his/her latest contributions. Once a critical event is detected, it often requires a collaborative effort to interpret the information, eventually collect additional information, to analyse causes, and to develop and decide on plans on how problems might be solved. While monitoring is an integral element of any kind of collaborative activity, participants often have to reconstruct the course of action by indirect cues (e.g., they have to wait until they get a response to infer that a mail they sent was actually read) or have to rely on their memories, as past events are not recorded elsewhere. Hence, automatic recording and presentation of relevant actions can foster monitoring.

Collaborative Retrospectives

Project retrospectives have been suggested as an important element of project-based work (Kerth, 2001) and have also been adopted as a means to learn from experience in student projects (e.g. Krogstie, 2009). In addition, project progress and direction is often assessed in interim review meeting, which might take the form of design reviews or 'steering group meetings' (cf. KP-Lab, 2010b). In comparison to the monitoring activities, collaborative retrospectives provide a more formal and systematic approach aimed at reflecting on past activities and deriving lessons learned for the future work. Although there is some variation in how collaborative retrospectives are implemented, their overall plot usually entails the following steps: (a) reconstruction of the activities that took place in the past; (b) identification of critical events that had an impact on the process and its outcomes; (c) analysis of possible causes that led to the critical events; and (d) summary of insights relevant for future work. Collaborative retrospectives are usually moderated by a supervisor or external facilitator. Furthermore, to avoid groupthink and to give room for multiple perspectives and explanations, collaborative retrospectives often comprise individual and collective phases. While in the individual phases each team member aims to explicate his/her own perspectives, the collective phases are aimed at comparing the individual perspectives and at coming to an agreement on implications for future work. Collaborative Retrospectives strongly rely on material that allows participants to anchor and reconstruct past activities. The collection of information and the smooth integration of individual and collective phases during a retrospective are recurrent bottlenecks in current practice.

Analyse and Compare Knowledge Practices

While this scenario is highly relevant for researchers, it also plays a prominent role for teachers and other stakeholders interested in assessment and evaluation of actual knowledge practices. For example, in the current research cases on trialogical learning in higher education, a main task for the teachers will be to reflect on the extent to which their interventions turn out to work as expected, or whether there are new practices emerging (cf. KP-Lab, 2010b). This kind of analysis goes beyond the other two scenarios in that it entails a comparison of activities across cases and, hence, can be seen as a form of reflection-on-practice. Consequently the analytic procedures to be used in this scenario are more complex. The overall analytic process in this scenario can be summarized as follows: (a) collection and organization of information from relevant cases/projects; (b) description of phenomena or patterns of events in a format applicable across cases; (c) cross-case comparisons to check for similarities and differences across cases; and (d) interpretation of findings in light of the information available and/or the analysts' background knowledge. Similar to the other scenarios, the analysis and comparison of knowledge practices might be carried out as a collaborative process, in which, for example, a teacher discusses students' practices with colleagues. A particular challenge in this scenario stems from the need to describe phenomena of interest in such a way that they convey the peculiarities of a given case, yet provide suitable level of abstraction so that comparison across cases is feasible.

Analysis and Reflection as a Knowledge Creation Process

Collaborative analysis and reflection on knowledge practices are central elements of the Trialogical Learning Approach. This involves also that interactions and transformations between tacit knowledge, knowledge practices, and conceptualizations of these are a driving force in processes of knowledge creation (Paavola & Hakkarainen, 2009). Drawing on this perspective, a number of challenges for the collaborative analysis and reflection on knowledge practices are pinpointed and presented below. These challenges are based on an understanding of collaborative analysis and reflection as knowledge creation processes, in which the participants advance their understanding of the knowledge practices at stake and device new options for future activities.

First, when dealing with knowledge practices, analysts are confronted with the inherent complexity and open character of collaborative activities. This complexity and openness of knowledge practices is due to the stratified nature of social interaction, ranging from individual operations over group activities to institutional processes as well as the interconnectedness of different processes (e.g. Langley, 1999). Additionally, as pointed out by Paavola and Hakkarainen (2009), today's knowledge practices cannot be defined in terms of rule-based routines but require a more dynamic, creative, and reflective notion of practice itself. As a consequence, technology in support of collaborative analysis and reflection has to go beyond the faithful representation of data and has to provide for collaborative exploration, including the means for the integration of different data sources, as well as the analysis of data from different perspectives. While most of the existing mirroring tools in support of computer-supported learning have been designed for rather well-defined educational settings with clearly defined boundaries, such approaches appear to be insufficient when knowledge processes are only loosely structured or if groups aim to transform their own practices. Similarly, as pointed out by Amar & Stasko (2004), many tools for information visualization are still focused on the faithful representation of data but hardly account for the uncertainty entailed in the data and the complexity of the decisions to be made.

Second, and closely related, is the fact that data and information about a given knowledge creation process is necessarily incomplete. This incompleteness relates not only to the data collected but also to the knowledge process as such, as well as the analysts' conceptions of the knowledge process at stake. Because of the openness of knowledge creation processes and the fact that a single person might be enrolled in multiple often temporarily- and physically-dispersed activity systems, it is impossible to point to all events potentially relevant for a given knowledge process. What is deemed relevant for a certain analysis is hence subject of judgment and social negotiation rather than objectively given. Similarly, the necessary incompleteness of data collected is due to the object of inquiry rather than failures in the instruments used. Even automatic data collection cannot guarantee the 'correct' recording of events. For example, during face-to-face meetings, students share a single computer – a fact not accessible from the log-files recorded. Finally, the analysts' conceptions of the knowledge creation processes at stake are usually also incomplete. Even though this problem might be attributed to the current state of theory development, a comprehensive theory of knowledge work is not yet available and appears unlikely, given the inevitable emergence of new knowledge practices. As a consequence, tools aimed at supporting reflection on knowledge practices have to account for the incompleteness of data, and the tentative nature of the analysts' conceptions about the phenomena at stake. Hence, rather than providing a fixed set of standard queries and examples, it is important to equip the user with flexible analytic functionalities.

Third, due to the focus on knowledge creation and practice transformation, there is a particular interest in this study in the identification and explanation of critical events. Such critical events might relate both to the outcomes of the work process and the knowledge practices employed. Therefore, collaborative analysis and reflection is often geared to explicate related processes in form of patterns suitable to diagnose future problems or to give guidance on how practices might be improved. These patterns can be understood as knowledge artefacts on their own, which are created in the process of collaborative analysis and reflection rather than being defined a priori. Towards this end, mirroring tools should support the iterative creation and refinement of such patterns, taking into account the fact that critical processes often mark exceptions rather than routine procedures.

Finally, the Trialogical Learning Approach emphasizes the social dimension of knowledge creation and practice transformation. Stressing the relevance of personal and collective agency (cf. Damşa & Andriessen, this volume) as well as the importance of different perspectives, analysis and reflection on knowledge practices requires the active engagement of all participants involved. Respective tools and methods, therefore, have also to account for the different backgrounds and conceptions of the stakeholders involved. Bringing together students, teachers or knowledge workers with different backgrounds and interests holds promise of cross-fertilization and knowledge creation but might also entail a collision of activity systems, generating disturbances and conflict (e.g. Gebert Boerner & Kearney, 2006). Hence, rather than superimposing authoritative normative assumptions about good or bad, productive or unproductive practices, mirroring tools should give room for the articulation of multiple perspectives and collaborative meaning making. Towards this end, it should also be ensured that the representational formats used are equally accessible to all participants.

DESIGN GOALS

To provide support for the different scenarios and to address the challenges outlined above, the following main design goals have been specified:

1. *Supporting the explorative analysis* of computer-supported knowledge processes: Rather than confronting users with predefined queries and indicators, the tools should enable users to make sense of the data themselves and in collaboration with others. Users should be able to filter, aggregate, search, and annotate the data. Furthermore, they should be able to follow traces of material evidence of their activities on different levels of abstraction, providing them with overview and detailed information when needed.
2. *Openness for external events*: As knowledge work seldom takes place in virtual environments alone but often comprises a complex mixture of computer-supported teamwork, face-to-face meetings and work on non-digital artefacts, users should be able to complement automatically recorded data by other sources of data, including their memories.
3. *Supporting multiple perspectives and intergroup comparison*: The tools should allow users to share and articulate different perspectives but also allow for comparisons across groups to foster cross-fertilization and exchange. Therefore, tools should provide mechanisms for exchange of queries, patterns and views as well as the possibility to annotate and comment on events.
4. *Providing meaningful and comprehensible visual metaphors which can be easily customized to the information needs of various categories of users*: To account for different backgrounds and levels of expertise the tools should offer visual formats that are both meaningful and comprehensible for different stakeholder groups. In addition, user interface mechanisms for data

manipulation and analysis need to be intuitive yet powerful to be of use, even for occasional users with limited background on data analysis.

TOOLS FOR THE INTEGRATED ANALYSIS AND REFLECTION OF KNOWLEDGE CREATION PROCESSES

To address the main design goals mentioned above, two new analytic tools, *Visual Analyser (VA)* and *Timeline-Based Analyser (TLBA),* have been devised.

The *Visual Analyser* allows users to analyse participation and activities within past or ongoing knowledge creation processes by visually representing them, based on information stored in the produced logs. More precisely, it visualizes frequencies of object-related activities and provides detailed information on the nature of the activities performed on particular knowledge objects. These visualizations allow users to reflect on the distribution and types of their activities with respect to time, type of object or subject, etc., as well as to compare events across different workspaces.

On the other hand, the *Timeline-Based Analyser* provides a chronological display of the recorded events and allows users to define and store possible external events, which could not have been recorded by the KPE tools. Moreover, it allows the tracing of actions related to a particular knowledge object and the defining of 'patterns' of actions that can be identified in the historic data.

Before describing both tools in more detail, we give an overview of the overall software architecture and the log format used. For more detailed information of the technical implementation (KP-Lab, 2010a).

Overall Software Architecture of the Analytic Tools

Figure 7.1 depicts the integration of Visual Analyser and the Timeline-Based Analyser into a virtual collaborative environment.

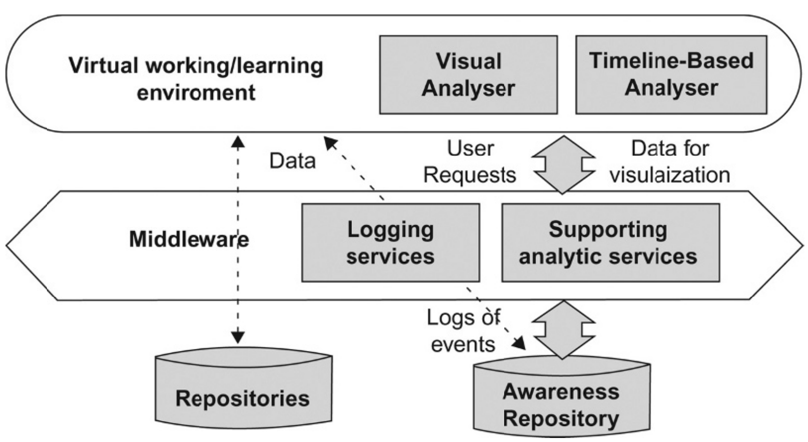

Figure 7.1. Architecture of the analytic tools integration with related supporting services.

Both the Visual Analyser and the Timeline-Based Analyser draw on middleware services for logging purposes (Logging services in Figure 7.1) and on an execution engine for specified queries (Supporting analytic services), which are accessed by the user via specific web-applications. In this way, the query formulation and visualization are separated from the internal query processing, which is hidden from the user.

The web-applications, which are integrated into the virtual working/learning environment, handle the interaction with the user, providing a graphical user interface for the selection and querying of recorded events, transforming users' requests into analytic queries and visualizing the results of the query.

The user-defined queries are evaluated by the Supporting Analytic Services against the historic log data, which is collected from users' actions within the virtual working/learning environment, and stored in a separate database called Awareness repository. The Supporting Analytic Services provide a range of services for selecting and aggregating data from underlying repositories, for defining external events, for commenting and semantically annotating all types of events, and for pattern description and identification.

All events are stored in the awareness repository in a predefined format of log (see below). This generic format was designed to provide complex information for analytic purposes and can be adapted to new, specific requirements by adding new parameters or removing some of the existing ones. While the Visual Analyser and the Timeline-Based Analyser are currently integrated and tested within the Knowledge Practices Environment (KPE) (cf. Lakkala et al., this volume) the format of log has also been tested in several experiments with other collaborative systems such as Moodle or Claroline (Babič, Wagner, Jadlovská & Leško, 2010).

The log format currently used includes the following 12 parameters for each event recorded:

- ID – unique identifier of the log entry;
- Type – a type of performed actions, e.g. creation, modification, deletion, etc;
- Actor – unique identifier of actor that performed the given event;
- Actor Type – user role that is delegated based on relevant part of the user environment;
- Actor Name – user name obtained from user management based on his system logging information;
- Entity – unique identifier of the object that motivates given event;
- Entity Type – type of object, e.g., task, document, link, wiki page;
- Entity Title – concrete title of related object;
- Belongs to – unique identifier of relevant part of user environment where this event was performed;
- Time – time when the event was logged into database (represented in the following format: year-month-day HH:MM:SS);
- Custom data and properties – these parameters are used in situation when end-user application will store some properties or data that are typical for it.

By the time of writing, the repository contains more than one hundred thousand logs from the Knowledge Practices Environment that represents a main testing environment for the proposed services.

Visual Analyser

The Visual Analyser is a tool that visualizes statistics of log data by summarizing the data according to users' requests. The major goal we have achieved through this tool is to enable untrained users without a background in data analysis to perform event data analysis through the following manipulations:

1. Construct an analytic query visually, in an interactive manner;
2. Dynamically visualize evaluation results of analytic queries;
3. Focus on interesting parts of a data set by changing aggregation level and/or defining filtering conditions.

The Visual Analyser interface can be categorized as an interactive Online Analytical Processing (OLAP) environment for a specific application domain. In contrast to existing environments and commercial products, we had the rare opportunity of developing the Visual Analyser by combining practical user tests with a formal approach for software architecture design.

User tests throughout the design process revealed that typical concepts for query formulation (e.g. classifiers, measures) used in existing OLAP tools were not necessarily familiar to the envisioned target groups. To perform explorative analysis as foreseen by design goal one, the tool has to allow users to easily formulate different analytical queries. Towards this end, the decision we have made on the interface design is to 'specify only *how to visualize it,* do not worry about *how to create it.* In the Visual Analyser interface, any textual database queries and concepts for formulating queries are completely hidden from users. The interface asks users only to associate data fields with parts of the visual representation. For instance, to visualize the number of log events by month, it is not necessary for users to formulate any kind of database query. Users only have to drag the 'month' data field from the visualized log data schema and to drop it into the 'X-Axis' placeholder. Then, the system automatically formulates appropriate analytical queries, evaluates them and, finally, presents visually the query evaluation results. Through this process, users can construct analytical queries without dedicated knowledge about concepts for query formulation.

Another interesting fact we observed during the development is that filtering is essentially important. The KPE event data contains many time-series events made by users. In a typical data analysis task, a user (student, teacher, or researcher) deals only with events related to a set of designated users (i.e. members of a limited number of workspaces) in a specified period of time. Moreover, an analyst often extracts a subset of data to see details of it, or to compare several different subsets of data. Carrying out an explorative analysis, an analyst has to create and adapt various data filters to slice and view data from various viewpoints. Against this background we decided to provide specialized methods for helping users to perform such filtering tasks, beyond existing general-purpose OLAP tools. Our tool implements query suggestion, special drag-and-drop action and a dialogue window for key value selection to make new filters under different situations of data analysis tasks.

Additionally, the Visual Analyser provides functionalities to export both analysis results and visualization designs for sharing with other users. In particular, by sharing visualization designs that also contains analytical queries, users can share the same perspective on the data and extend their own perspective by modifying shared visualization designs.

From a theoretical perspective, the Visual Analyser has been developed through a formal analysis of the visualization process of the log data. In our approach, we analysed both the given log data schema and the visualization schema by using the functional data model – a high-level formal data model. This approach allows us to clearly understand the relationship between data and visual representations, and to naturally derive mechanisms for realizing many features of the Visual Analyser, including visualization design by drag-and-drop, automatic query formulation and interactive data filter construction.

To be more precise, functional model structures data based on existing functional dependencies. On the other hand, visual representations of data are also built according to some constraints. When the user defines the desired visualization, the system compares constraints on the data with constraints on the required visualization, and identifies the corresponding valid query.

In the example depicted in Figure 7.2, the user drag-and-dropped ‘User Name’ from the schema to the X-axis of the visualization, and ‘Event’ to the Y-axis, in order to compare number of Events for each User, based on the bar-charts. According to our visualization constraints, each value of the X-Axis should determine the height of a bar. So there should also be a dependency in the data schema between what is placed on the X-axis, and what is placed on the Y-axis. However, there is no dependency UserName -> Event in the data schema. In such case our system creates a new node: *‘Total number of Events by User Name’,* and places it on the Y-axis, which allows result visualization, and represents exactly what the users meant when creating his query by drag-and-drop.

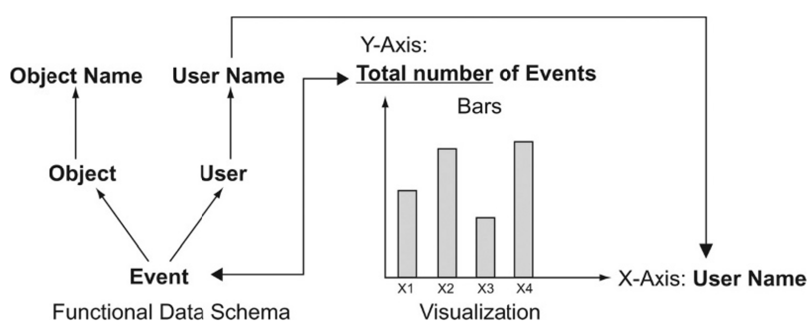

Figure 7.2. Depicting functional dependencies to formalize and visualize data relationships.

Such a formal approach forms a striking contrast with a typical design approach for domain-specific visualization environments, which associates data to visual representation by direct but ad hoc ways (for more details, see Sugibuchi, Spyratos & Simonenko, 2009; Spyratos, Simonenko & Sugibuchi, 2009). Through repetitions of such formal analysis and real user tests, we have succeeded in polishing the Visual Analyser system as a simple but powerful environment that provides smooth log analysis experience.

Timeline-Based Analyser

In contrast to the Visual Analyser, the Timeline-Based Analyser does not present events in an aggregated form, but visualizes recorded events in a chronological order based on users' interaction with the objects created. Hence, the main aim of the Timeline-Based Analyser is to provide users with a means to explore the network of activities as it unfolds in time, and to analyse and reflect on the respective processes. Rather than focusing on quantitative indices, the emphasis of the Timeline-Based Analyser is on the qualitative analysis of events.

Toward this end we faced two main challenges, which relate to the logs as the primary data source, as well as appropriate means to specify and search for patterns in collaborative knowledge creation processes.

Firstly, although log-based data is easy to collect and process automatically, it provides, in itself, hardly any information about the purpose or meaning of a particular event. Furthermore, without contextual information log data can easily result into misleading interpretations (Avouris, Fiotakis, Kahrimanis, Margaritis & Komis, 2007). Descriptive frameworks for collaborative learning processes, such as the Object-oriented Collaboration Analysis Framework (OCAF) (Avouris, Dimitracopoulou, Komis & Fidas 2002), therefore, usually combine log data with other sources of information to identify the functions of the actions recorded. While this approach seems adequate for research purposes, extensive manual coding of events, required for the identification of functional roles, appears to be out of scope for the application scenarios we envision. Hence, the Timeline-Based Analyser is supposed to directly build on data that can be collected automatically, providing the possibility of adding contextual information and defining functional roles as a non-mandatory option.

The second main challenge relates to the identification of regularities and patterns within the data collected. From a process analysis viewpoint, several relevant approaches can be found. Tools for process mining, such as ProM, are usually meant to extract a process model from an event log or to detect discrepancies between a predefined process model and an event log (Van der Aalst et al., 2009). While this approach is well suited for highly structured processes, such as business processes, it is not suitable for less structured processes like knowledge creation processes, as these are temporal, noisy, correlated, incomplete, and often only a small amount of data is available (cf. Perera, et al., 2009). Furthermore, as interesting knowledge practices often do not occur frequently (rendering inductive learning techniques employed in data mining useless), we adopted a combination of timeline-based visualization of knowledge creation processes (with the possibility of highlighting and commenting upon particular events, and also adding external events) and the means for manual definition of patterns within this framework. To our knowledge, there is only one study where a similar idea had been presented (Psaromiligkos, Dimitracopoulou, Komis & Fidas, 2009). Based on published screenshots, the tool seems to provide a very difficult GUI, not suitable for casual users, as the Timeline-Based Analyser is designed for.

Timeline-Based Visualization and Exploration

To provide a meaningful and comprehensible overview of the actions carried out in a collaborative working space and to discern who performed those actions, logged events are mapped on separate timelines, each of them representing a particular user (cf. Figure 7.3). Different types of actions, such as creation, opening, modification and deletion, are represented by type of icon, while events involving the same object are linked together. In this way, the user can easily trace an object's path trajectory in terms of the intensity of manipulation, the type of actions carried out, and the participants involved in this process. Upon selection of an event, additional information such as the title or type of the object is displayed.

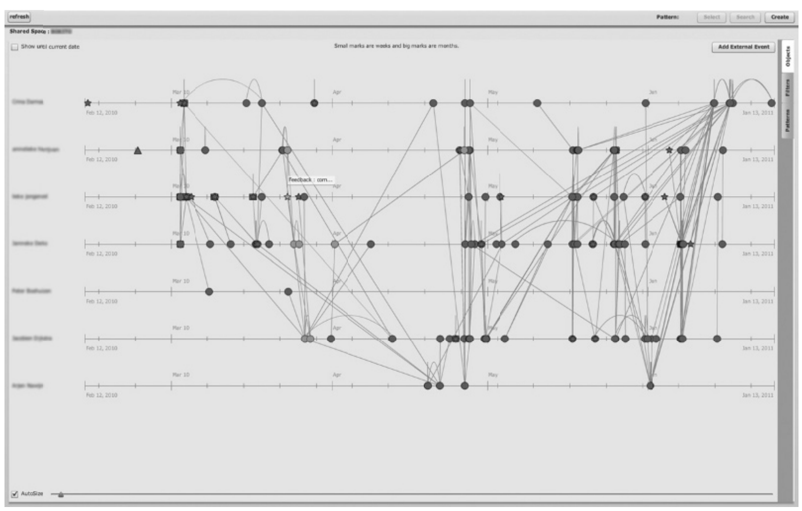

Figure 7.3. Graphical user interface of the Timeline-Based Analyser.

Although this kind of display can become quite messy and the sequence of events might be hard to discern, if events follow each other rapidly, this visualization preserves the entire information stored in the log data, avoiding unnecessary distortion due to pre-selection or aggregation of data. To focus on and explore events of particular interest for the analytic task at hand, the Timeline-Based Analyser provides the means to filter events by type of object or type of activity, as well as restricting the time interval displayed. Furthermore, upon selection, object's path trajectories are highlighted, allowing the tracing of all events related to a particular object. Events currently not in focus are greyed out but still visible to provide a stable point of reference for the user and hence improve orientation.

Additionally, the Timeline Based Analyser allows users to add external events to the timelines to indicate that some external event, not recorded by the system, had taken place that relates to one of the objects stored in the system. For example, an online document might be discussed in a face-to-face meeting, giving rise to a reassessment of its relevance to the project at stake. The Timeline Based Analyser ensures openness for external events and allows it to complement automatically recorded data by other sources of data.

Patterns

Supplementing the basic functionalities described above, the Timeline-Based Analyser allows users to design and share their own analytic queries by building, searching, and sharing event patterns. Thereby, a pattern is understood as a suitably generalized set of selected events or elements from the timeline, providing well-formalized projects of interesting practices or part of a knowledge creation process.

Starting from the assumption that knowledge creation processes are complex, often unique and ill defined, and hence cannot be fully described by some well-defined, rigid process structure, traditional approaches to process modelling fall short as they cannot cope with the informal aspects inherent to these processes. To cope with this problem, we introduced a structure called patterns to generalize this type of processes. These patterns do not completely describe the knowledge practices as such but they are able to formally and explicitly define at least some parts of them. Formal pattern description is used for searching occurrences of such practices in logged data, representing performed practices/activities/processes in a virtual working or learning environment. The goal of this search is to discover other occurrences of the defined pattern, which serves as a supporting analytical feature for users, teachers or researchers to analyse and understand events in the virtual environment.

The Timeline-Based Analyser supports the definition of patterns, either from scratch or based on any subset of events presented on a give timeline, with the possibility of relaxing some of the attributes of selected events. In this way, a set of constraints is stated. For example, the following set of events might be selected from a given timeline display:

1. A user (anyone) uploads a document.
2. Another user (anyone except the one who uploaded the document) reads this document.
3. The user who read the document posts a comment to the content item, which contains the document.
4. A third user opens this comment and reads it.
5. The same user updates and uploads the document.

Figure 7.4 shows a possible match for the above pattern.

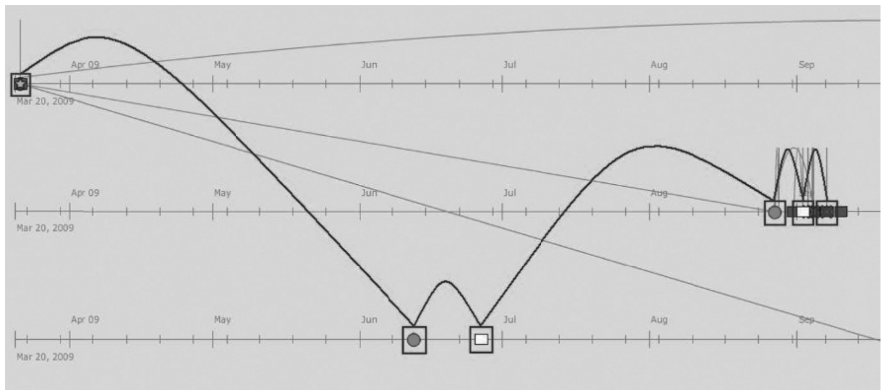

Figure 7.4. A possible match for the pattern described above.

As mentioned before, patterns can be defined on the basis of existing events, as well as from scratch. Once a pattern had been defined, it can be stored and exchanged with other users and searched for occurrences in other contexts.

DEMONSTRATION

In this section we provide illustrative examples on how both the Visual Analyser and the Timeline-Based Analyser can be used to support analysis and reflection.

Explorative Analysis

This case study focuses on a researcher's attempt to analyse and understand students' collaborative learning processes by means of the Visual Analyser. It is based on collaborative design projects of student teachers, carried out at the STOAS University of Applied Sciences in the Netherlands. The researcher had been introduced to the Visual Analyser and was familiar with its main features. At this point, she had not yet used it for actual research purposes. The case study is based on her own documentation of the analytic process and a retrospective interview. The researcher's analyses were based on: (a) activities of four student teams in the Knowledge Practices Environment, recorded over a 5-months period; and (b) field data, including field notes, artefacts produced by the groups, recordings of face-to-face meetings, e-mail correspondence and self-reports. These analyses aimed to characterize and compare the collaborative learning processes of the four student teams and to understand the role of tool support in this process.

The overall process of the analysis can be divided into three main phases. In the first phase, the researcher produced an account of the overall process, aiming at an overview on the general *sequencing of course activities and group work*. This overview was then complemented retrospectively with information from teachers and students, which resulted in a general assessment of the collaborative project and activities. In the second phase, the focus of analysis shifted from the course and collaborative settings as such toward the analysis of the *activities within the four groups*. In addition to an analysis of the groups' activities, based on observational data, e-mails and artefacts produced, the researcher used the Visual Analyser to generate a cross-group overview of the amount and type of activities performed (cf. Figure 7.5).

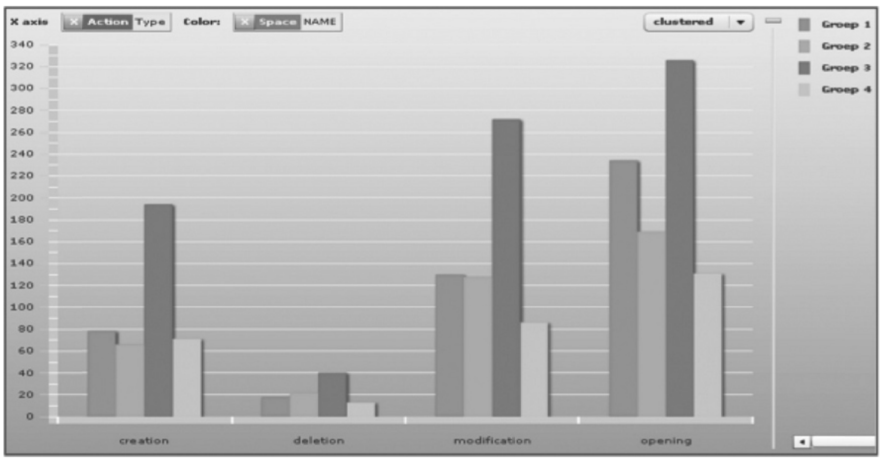

Figure 7.5. Cross-group overview of amount and types of activities.

The researcher interpreted Figure 7.5 taking into account the results from previous analyses. While group 3 (darkest bar) was the most active, the graph revealed a rather low amount of activity for group 4, which, according to her observations, was a rather active group. On the other hand, based on the insights provided by the observational data, group 2 appeared to be more active than expected. To understand these discrepancies, the researcher decided to have a closer look into the activities by performing an analysis of the qualitative data recorded (i.e., recordings of group discussions, e-mails, products). Using another query, the researcher mapped the four group's level of activity on a timeline (cf. Figure 7.6).

Figure 7.6, see below, revealed a peak of activities in the second project month, followed by a reasonable level of activity in the next two months, while in the first and last two months activities were rather limited. Confirming the interpretation of the first graph, the graph shows that group 3 was the most active group of the four. However, at this point, the researcher decided to resort to the actual logs (provided by the environment's data export functionality) to gain better insight into the type of activities performed during each month.

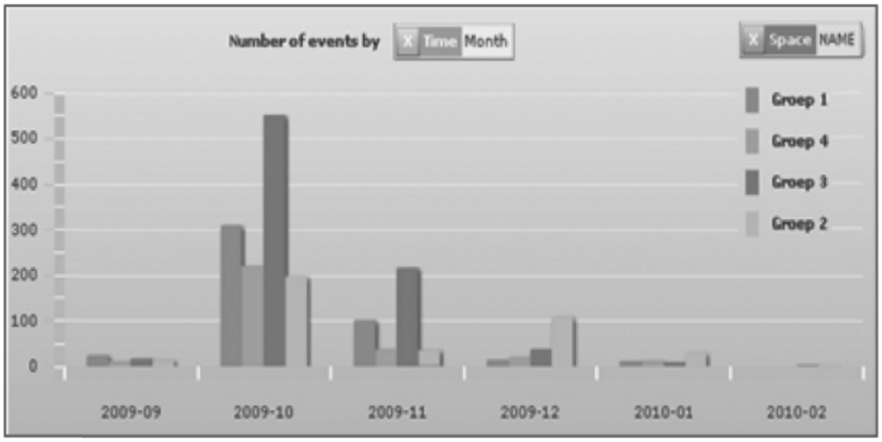

Figure 7.6. Overall activities in the four groups per month.

In the third phase, the analysis of the four groups' activities was extended towards the *role of tool support.* This analysis started with a visual inspection of the workspaces used by the groups, as well as the contents created and uploaded to the environment. This inspection provided some first indications on how the tools were used by group members. The results of the inspection were in line with the researcher's observations regarding the different ways the four groups had organized their collaborative process.

Figure 7.7 is an example of the researcher's attempt to understand how students used the tool. The researcher ran a query, which produced an overview of types of action performed and items produced per user.

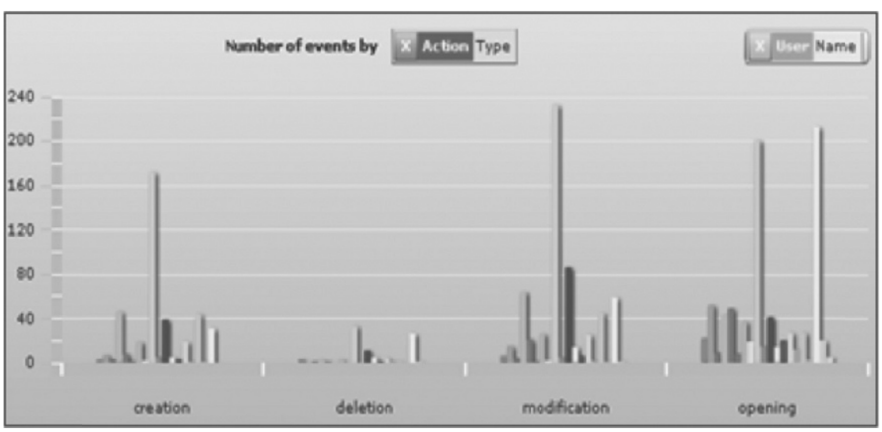

Figure 7.7. Types of action per user.

With regard to Figure 7.7, the researcher noted that '*there were a number of users from each group who were active in organizing work in the space and other users being active only in Opening or Modifying items or tasks.*' She went on and cross-checked this idea with statements of the students in the retrospective interviews. Next, she modified the query and aggregated data by object type instead of action type (cf. Figure 7.8). Later, she tried to understand how groups worked with items and ran a query providing an overview of object types per group.

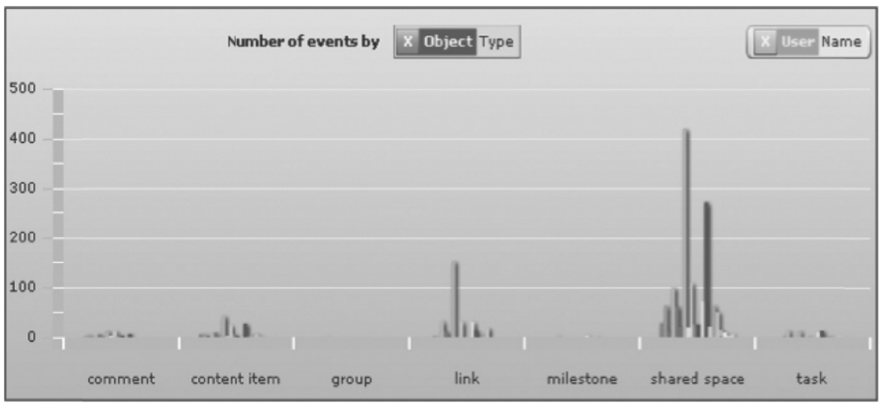

Figure 7.8. Types of object per user.

Two issues appear particularly important in this case study. First, it shows that the researcher does not use the Visual Analyser in isolation but, in fact, draws on a variety of other sources to probe her understanding of the collaborative activities. In a similar way, she also moves between within- and cross-group comparisons to explore possibly interesting processes. Second, the case study shows that the research does not use a set of predefined queries but that the analyst must develop and refine the queries iteratively.

Collaborative Retrospectives

The aim of this second case study is to describe how timeline-based visualizations can be used to foster collaborative reflection in student project teams and how this process might be enhanced by use of the Timeline-Based Analyser. This case study is based on a collaborative retrospective carried out in connection to a compulsory project-based course at the University of Applied Sciences Upper Austria. The Collaborative Retrospectives were facilitated by a research assistant and took place at the end of the course. The pedagogical intent of the retrospectives was to give students an opportunity to reflect on their working practices and to derive lessons learned for future projects (cf. KP-Lab, 2010b). Before we show how the TLBA can be used to support these processes, we first describe how the collaborative retrospective actually had been carried out without usage of suitable IT-support.

The Collaborative Retrospectives lasted 60 minutes, on average, and were divided into six steps. Following a brief introduction on the purpose of the meeting (step 1), students were asked to recollect the main activities relevant to their project and note them down individually on a printed timeline (step 2). Course meetings and short descriptions of related assignments were added to the timeline beforehand to provide some anchoring point for the students. Students were then asked to explain to the group the activities they had noted, while the facilitator made notes on these events on a large-scale print out of the same timeline (step 3). Once all activities were added and organized chronologically, the students were asked to return to their individual printouts and to mark those events they perceived as having an impact on their project. Besides adding short notes on the event itself, they were also asked to rate whether the perceived impact was positive, negative or neutral (step 4). Afterwards students were asked to transfer the events they deemed critical to the shared timeline, whereby the position of the marks was meant to indicate both time and perceived impact. Then, students were asked to inspect the shared timeline and discuss those events they felt most relevant for the entire team, while the facilitator encouraged participants to elaborate on divergent perspectives, to think about possible causes, and how they could be avoided/triggered in the future projects (step 5). In a short wrap-up students had time to add further comments or ask questions (step 6).

Figure 7.9 depicts a shared timeline created in one of the project retrospectives. According to students, the group had encountered a ‘crisis’ in the middle of the term, which resulted in a rethinking of the project idea and a re-adjustment of the project objectives. When asked to identify and rate the critical events of the project (marked with stickers on the timeline below) it became apparent that the team members assessed the ‘crisis’ quite differently. While two members pointed out that the crisis lead to a significant improvement of the concept under development, the third student admitted that he still was partly in favour of the original concept, which had been closer to his own ideas and interests.

Even though the collaborative retrospectives turned out as quite productive and were assessed positively by the students, the case study revealed some limitations of the current method. In particular, the paper-based format only allowed us to provide students with the most general events that applied to all teams, i.e. the course meetings. Consequently students had to recollect most events and their chronology from memory. In comparison, the Timeline-Based Analyser provides specific information directly related to the teams’ work processes. Consequently, less time is needed to reconstruct the work processes and more effort can be spent on the actual analysis. Figure 7.10 shows a screenshot of the Timeline-Based Analyser depicting the online activities of the project mentioned above.

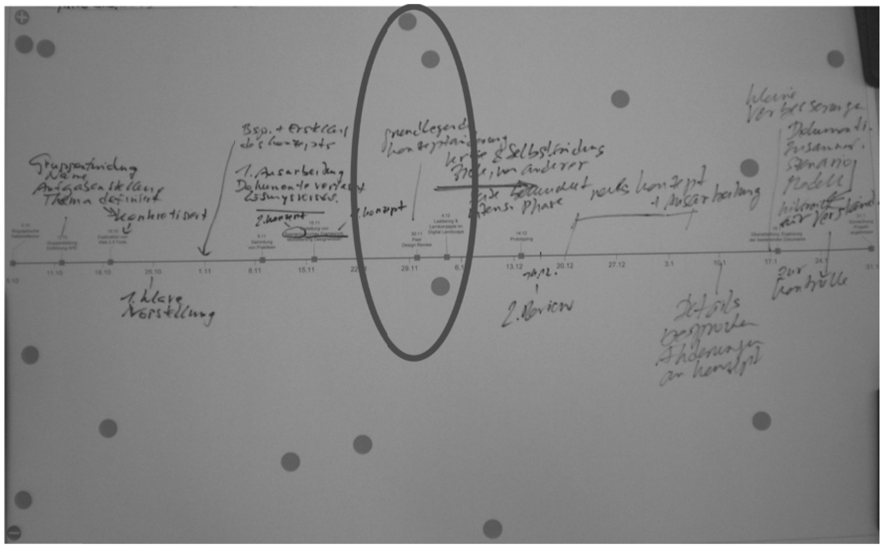

Figure 7.9. Paper-based timeline, circled events relate to the 'crisis' reported by the team.

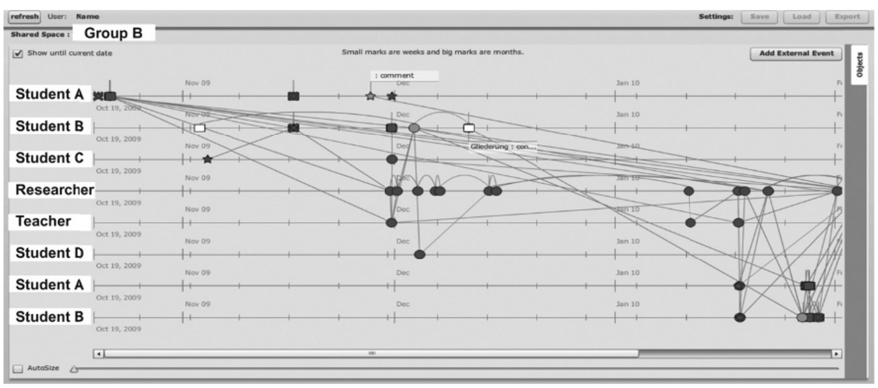

Figure 7.10. The Timeline-Based Analyser displaying activities of the same project team.

Besides providing general input for reflection, the pattern functionality of the Timeline-Based Analyser can also be used to explore critical events in more detail. For example, with regard to the 'crisis' mentioned by the project team above, it might be interesting to know whether the new proposal put forward by one student actually built on previous work. To test this idea, a pattern can be specified in which a user first opens a content item, created by someone else, shortly before creating a new document him- or herself. If such a pattern can be found in relation to the critical event, it provides some indication that it is likely that previous work was taken into account. Using the pattern function in the above case indeed resulted in a match directly related to the 'crisis' (cf. Figure 7.11).

Although the results provided in this case are inconclusive in themselves, they can provide important input for further discussions with the teams involved.

Besides this, we found that the mixture of individual and collaborative reflection is quite important in giving room for divergent opinions and avoiding premature consensus. Sitting around a table and working on a set of printouts, it can be tempting to start group discussion instead of focusing on one's own ideas. Working with digital media might make it easier for participants to focus on their own ideas while still being able to share results easily.

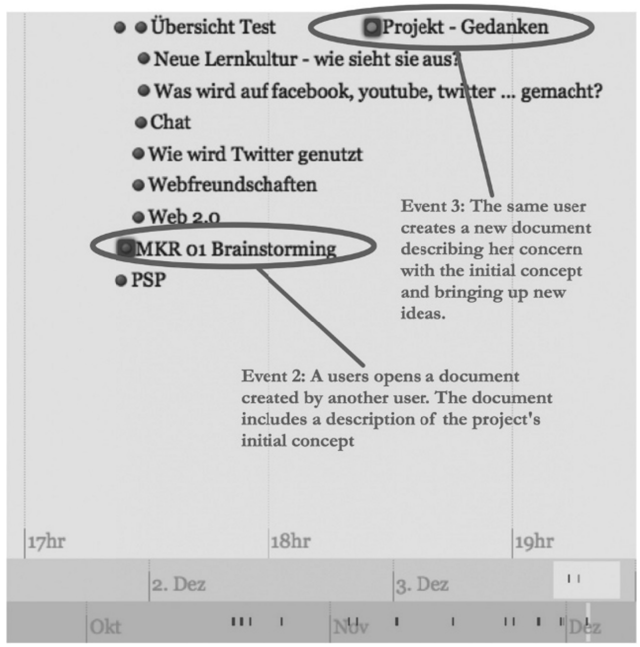

Figure 7.11. Highlighted events matched to the pattern definition; note that in this case an alternative timeline-display has been used.

CONCLUSIONS

In summary, mirroring tools in support of collaborative analysis and reflection not only have to provide means for the faithful and comprehensible representation of data collected but also for sustained and collaborative exploration and interpretation. The Visual Analyser and the Timeline-Based Analyser described in this paper have been tested for usability and used by researchers in the KP-Lab project. Furthermore, initial trials with teachers and students had been carried out in real-world settings, hinting at promising feedback with regard to the utility of both tools in practice.

While building on the state of the art in the fields of Data Mining, Knowledge Discovery, and Computer-Supported Collaborative Learning, these tools emphasize the active role of the users in the process of data analysis and interpretation. Rather than providing direct guidance on what to look for, they are meant to encourage users to explore and make sense of the data themselves and, hence, provide a meaningful starting point for practice transformation. The case studies included in this chapter are quite tentative but, nevertheless, they illustrate the complexity of the analytic processes we aim to support. While the first case study highlights the explorative nature of the analytic process and the need to move between and draw on diverse sets of data, the second case study sheds light on collaborative reflection of practices as a social process bringing together people, with different perspectives and aspirations.

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8. USING TRIALOGICAL DESIGN PRINCIPLES TO ASSESS PEDAGOGICAL PRACTICES IN TWO HIGHER EDUCATION COURSES

INTRODUCTION

Design-based research has become a popular methodology in educational research because it provides results that can explicitly be applied to inform pedagogical practice, unlike surveys or experimental studies conducted in controlled laboratory settings (Brown, 1992; Edelson, 2002). One basic aspect of design-based research emphasised by many researchers is that it combines empirical research and theory-driven design of educational settings, aiming to understand how to assess and improve pedagogical practices in authentic contexts, and simultaneously develop the theories further (Bell et al., 2004; Design-Based Research Collective, 2003).

One recent approach to designing complex learning settings is to define generic *design principles* that explain the central features of a pedagogical approach to guide the designer (Kali et al., 2009). Design principles may be theory-driven or constructed inductively from empirical findings. Theory-driven design principles are intended to support the evaluation or construction of an educational setting with guidelines based on a specific learning theory; in this sense, they can be regarded as normative, defining conditions for "ideal learning" (on the basis of the theory in question). Data-driven design principles, according to Bell, Hoadley and Linn (2004), form an intermediate step between research findings that need to be reproducible and generalized and practical examples from unique educational settings. They are used as heuristic guidelines for improving educational practice rather than for falsifying scientific laws.

A well-known example of theory-driven pedagogical design principles is the set of knowledge-building principles introduced by Scardamalia (2002). In the context of activity theory, Kaptelinin, Nardi and Macaulay (1999) offered a theory-driven 'Activity Checklist' for designing and evaluating the usability of computer technology. Examples of empirically constructed design principles include the Scaffolded Knowledge Integration Framework (Linn, Davis & Eylon, 2004), and a design principles database (Kali, 2006).

In accordance, design principles can be used to design new educational units by educational researchers or practitioners as well as to assess or evaluate current educational practices in order to move them towards the ideal pedagogical

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approach behind the principles. For instance, Lee, Chan and van Aalst (2006) used a subset of knowledge-building principles to investigate how students themselves could use the principles to guide their self-reflective activities as part of a collaborative knowledge-building endeavour.

The motivation of our study is the current challenge for educational institutions to develop their teaching practices to support students in acquiring a diverse range of competences for modern knowledge work as addressed in several policy papers (e.g., Ala-Mutka, Punie, Redecker, 2008; Johnson, Smith, Willis, Levine & Haywood, 2011). Present-day university students will probably be employed in positions that require ability to apply technology for knowledge creation and collaboration. Knowledge work in the globalized economy is increasingly done in spatially and temporally distributed multi-professional teams, mediated by digital technologies. In educational practice the required competences are not well addressed. These include 21st-century skills or digital competence, applied to co-construction of things in complex real-life settings and enabling participation in virtual communities of a networked society (Jenkins, Clinton, Purushotma, Robinson & Weigel, 2006; Muukkonen, Lakkala, Kaistinen & Nyman, 2010).

To explicate core issues that require attention in educational transformations, Paavola and Hakkarainen (2005) introduced the idea of the *trialogical approach to learning*, which emphasizes the importance of organizing learning settings to promote the modern knowledge work competences of students. In the trialogical approach, deliberate engagement to advance shared workable knowledge artefacts and practices are considered as the third, essential element, adding to individual efforts ('monological') and community participation ('dialogical') (see, e.g., Paavola, Engeström & Hakkarainen, this volume). As part of the KP-Lab (Knowledge-Practices Laboratory), a set of *Trialogical Design Principles* was developed to describe the basic elements of the trialogical approach and guide its implementation into pedagogical practices and supportive digital technologies.

The present article describes how the trialogical design principles were applied for examining existing pedagogical practices in two higher education courses. Within the trialogical approach, the aim is to develop pedagogical practices and tools that emphasise the organisation of learner activities around shared objects that are created for some meaningful purpose or reason. For instance, in the first course investigated, engineering students learned professional project work by jointly producing real multimedia products for customer companies. In the second course, behavioural science students iteratively revised digital concept maps for explicating their conceptualizations and improving their competences in using qualitative research methods in their own studies. We investigated the ways two teachers structured student activities in these courses, aiming at expert-like collaborative knowledge practices in various ways. The results allow us to suggest recommendations that might be appropriate for developing the course designs and related tools further. Finally, the research exercise is used to discuss how the trialogical design principles could be applied in informing the future design of educational settings for actualizing trialogical learning.

TRIALOGICAL DESIGN PRINCIPLES

The trialogical design principles have been collaboratively developed through several iterative cycles to explicate the central ideas and features of the trialogical approach to learning (Paavola et al., 2011). The theoretical background of the principles goes back to the knowledge-building approach (Bereiter, 2002) and to the research on technology-enhanced collaborative inquiry (Muukkonen, Lakkala & Hakkarainen, 2005). However, it broadens these approaches using socio-cultural perspectives (e.g., Engeström, 1987) and more generally with the models representing the so-called knowledge-creation metaphor of learning (Paavola & Hakkarainen 2005). In the KP-Lab project, the trialogical design principles were meant to be multifunctional: a) to point out central features of the trialogical approach, b) to inform both the selection, design and evaluation of knowledge practices to be examined, as well as c) to design new digital tools for supporting innovative knowledge practices in education and the workplace. The design principles were revisited and elaborated during the project. They are quite abstract and general, but have been used as heuristic tools to explicate the kind of knowledge practices that were supposed to be emphasised and promoted.They are not standards or models that should be followed strictly but should be elaborated using the cases. The set of the trialogical design principles used in the present study consists of a list of six principles:

DP1. Organising activities around shared objects
DP2. Supporting interaction between personal and social levels and eliciting individual and collective agency
DP3. Fostering long-term processes of knowledge advancement
DP4. Emphasising development through transformation and reflection between various forms of knowledge and practices
DP5. Cross-fertilization of various knowledge practices across communities and institutions
DP6. Providing flexible tool mediation.

The most important principle in the trialogical approach is *DP1: Organizing activities around shared objects*, which specifies that collaboration should be organised for jointly developing some actual shared objects for a meaningful purpose. These shared objects may, for example, be conceptual artefacts (significant in knowledge building; Scardamalia & Bereiter, 2003), collective activity systems and social practices (important in activity theory; Kaptelinin, Nardi& Macaulay, 1999), or products and design plans developed in companies (significant in the model of organizational knowledge creation in Nonaka and Takeuchi, 1995). A crucial characteristic that the first principle attributes to shared objects is that they allow collaborators to externalize their knowledge creation efforts into tangible artefacts being iteratively elaborated.

The remaining design principles perform a crucial but subordinate function in relation to the first. Each specifies a distinctive condition as well as particular forms of mediatory mechanism required for realisation of the first design principle and regulating activities around shared objects. In *DP2: Individual and collective* *agency*, the focus is on processes through which people integrate their own personal work and group work by co-constructing shared objects, dividing labour, defining various intermediate tasks and deadlines for combining the expertise of participants and their contribution to collective achievement. A distinctive mediatory mechanism of these joint processes is that shared objects are worked on, taking into account the personal knowledge base, perspectives and interests of the participants. An outcome of integration between individual efforts and collaboration between participants is that shared objects and the goals regulating collaborative activities are incrementally clarified and modified. This principle also relates to the elicitation of *epistemic agency* (Scardamalia, 2002), both the agency of individual participants in advancing their own efforts and collective agency supporting collaborative knowledge advancement being important.

DP3: Fostering long-term processes specifies that the emphasis in trialogical practices is on long-term knowledge-creation processes in which shared objects are developed in a sustained way through multiple iterations or for some subsequent use. We claim that true knowledge creation requires time, effort and continuity (from individuals, groups, and social institutions). It should be built on the participants' previous efforts and achievements as well as a societally established knowledge base and expertise. One aspect of fostering long-term processes is that the re-use of previous, existing practices and knowledge artefacts is taken into account in developing new outcomes. Another aspect is the deliberate pursuit of elaborating joint knowledge objects and practices through several iterative revision rounds, which is not common in conventional educational practice. Third, constructing the outcomes for some relevant purpose or subsequent use is considered as an essential element of the collaborative trialogical effort.

DP4: Transformation between various forms of knowledge emphasises the parallel development of individuals, communities and outcomes through interaction between various forms of knowledge as well as practices and conceptualizations. Participants should be directed to deliberately examine knowledge in various representational modes and to apply declarative and conceptual knowledge in practical problems and articulate tacit knowledge. Not only the shared objects but the emerging practices surrounding them should be reflected by means of various tools and ways of modelling. This is especially important when the aim is to create something new; that is, not to repeat something already known or done before. Knowledge creation does not advance in a straightforward way but does so in ill-defined tasks where new ideas and practices are produced, tested through concrete actions, and constantly evaluated and revised through deliberate efforts.

According to *DP5: Cross-fertilization*, the trialogical approach highlights the importance of combining knowledge, expertise and practices from various fields and working contexts. For instance, the special interest in the KP-Lab project was in those knowledge practices where students are given assignments outside their own institution in order to *cross-fertilize* the expertise and practices of educational institutions and professional communities. In educational settings, the trialogical approach is meant to direct people to solve complex, authentic problems, learn professional knowledge practices from experts in the field, and produce outcomes for purposes outside educational institutions as well. It relates to cross-fertilization of knowledge practices both between various educational institutions (like polytechnics and universities) and between educational institutions and professional organizations (Heylighen, Lindekens, Martin & Neuckermans, 2006). Shared objects are considered not only in terms of individual, specialized fields of knowledge but multiple fields and contexts of practices, knowledge and expertise. Creating productive connections between academic and professional communities requires boundary-crossing (Kerosuo & Engeström, 2003) from all partners involved. Reciprocity, the co-construction of objects in multidisciplinary teams and mutual transmission and appropriation of varying practices across fields, communities and institutions are essential to cross fertilization.

DP6 Providing flexible tool mediation explicates the central role of mediating tools in knowledge creation activities. The trialogical approach is based on the idea of *mediation*; that is, activities of human beings are passed by tools, signs, artefacts, and social practices that people can develop collaboratively, with cultural means (Paavola & Hakkarainen 2009). The KP-Lab project focused on development of flexible tools based on modern digital technology for mediating and enhancing collaborative knowledge practices (Bauters et al., in this volume, and Lakkala et al., 2009).

RESEARCH QUESTIONS

The aim of the present study was to examine how the trialogical design principles can serve as criteria for evaluating existing pedagogical practices in higher education. The main research questions were:

1. How did the teachers structure the students' activities in the case studies and, based on the analysis, what recommendations can be suggested for developing the pedagogical designs and the tools further?
2. Does the set of trialogical design principles provide a useful tool for examining the teachers' pedagogical practices and the participants' experiences of the practices in the case studies?

METHODS

Educational Settings

The two higher education examples were case studies from the Finnish test sites as part of a broader set of studies conducted during the first phase of the KP-Lab project (Lakkala, Muukkonen & Sins, 2007). These courses had already been carried out and iteratively developed by the teachers several times before the study. The courses were originally not designed according to the trialogical approach; rather, they were chosen for investigation as existing "best-practice" examples to evaluate how current pedagogical practices satisfy the trialogical design principles. By investigating these courses in the KP-Lab project, we set out to create new models about knowledge practices in education to be propagated for other educational practitioners in higher education institutions.

Case study 1: Media project

Case study 1 was a compulsory term project in the domain of media engineering, targeted at third-year media technology students at EVTEK (later Metropolia) University of Applied Sciences, Espoo, Finland. The goal of the course was to engage students in applying collaborative design practices and project-based learning methods to solving the practical problems of media technology. Student design assignments were given by real customers, i.e., guiding students towards the knowledge and skills needed in working life. The course lasted about four months, including four joint meetings and several team meetings among the students and with the customers. A continuum of similar seminars is built into the study program in successive years. By attending these seminars, students gradually build their knowledge and improve their competence in managing projects and dealing with real situations when designing a product or service for and with a client. Students were meant to conduct a realistic design task for a real client (e.g., a multimedia product or a website application), using professional design project models, methods and multimedia tools.

The teacher had run the course several times during the last 15 years and was very experienced in designing and organizing processes of this kind. He maintained a large network of contacts with suitable customers that could generate various assignments to be offered to student teams. In all, 39 media technology students participated in the course; most of them (n = 30) from the 3rd year.

The bulk of the course consisted of project work periods during which the teams worked independently among themselves and with the client, and posted the specified project documents, such as a project plan, prototype, or final report, onto a shared virtual system. The students were free to conduct the project alone or in teams and to choose the customer and project objective from those that the teacher offered or to seek for a project themselves. Most students worked in small teams carrying out their design assignment. Some were paid for their project work by their customer. Students communicated directly with the representatives of the client organization, developing drafts and final products through close collaboration and joint meetings with them. Since the final products were designed for actual use in the client organizations after the course, students had to take into account the real needs of the clients' domains. In one lecture, a former student presented "lessons learnt" viewpoints and guidelines for avoiding the pitfalls of project work. At the last course meeting, each team presented their project to the other course participants. In addition, each student and each team was given the assignment of writing a self-evaluation at the end of the course.

An intranet system, OVI-portal, generally used in all EVTEK courses, was used as a forum for arranging student course participation, announcements, materials and task assignments. All lectures and presentations conducted in the course were videotaped and made available for the participants afterwards through the web. The teacher organized the delivery, sharing and monitoring of the project team documentation through a web-based project tool, NetPro, developed at EVTEK. In addition, the students were provided with various professional multimedia tools for creating the multimedia products designed by their teams.

Case study 2: Qualitative methods seminar

Case study 2 was a voluntary seminar about qualitative research methods at the Department of Psychology at the University of Helsinki, Finland (Kosonen, Ilomäki & Lakkala, 2010) targeted at students currently working on their master's or doctoral theses. The aim was to support their research practices, especially using qualitative methodology, in the practical context that their own theses provided. Research methods are often taught in higher education through lecturing complemented by small-scale practical exercises, but such general methodological courses do not usually match the students' needs in their own research assignments (Benson & Blackman, 2003; Edwards & Thatcher, 2004). Practices in the seminar were planned to simulate the knowledge practices of a real research community. Throughout the seminar, students conceptualized their understanding about various research methods by collaboratively creating concept maps. In addition, the students' own research for a master's or doctoral thesis was employed to provide a "real-world" context and motivation for applying qualitative research methods. The aim was to support long-term work with the methods and combine study practices with professional research practices.

The course teacher was a researcher in technology in education who had used qualitative methods widely in her own studies. In all, six undergraduate and post-graduate students participated in the course; it is a typical practice in university education to keep the number of participants small in seminar-type courses. The seminar lasted six weeks, including one face-to-face meeting each week. A total of 14 hours were allocated for the group meetings with the teacher and the students, and 66 hours for the students' individual work.

Particular software, CmapTools (http://cmap.ihmc.us), was used for enabling and facilitating the creation and iterative modification of the concept maps in pairs. A web-based collaboration environment, FLE3 (Future Learning Environment; see http://fle3.uiah.fi), was used for sharing the process (background materials, presentation documents, discussions and comments) between course participants both during and between the seminar meetings. In addition, ordinary office applications were used by the students. A technical assistant was present at the meetings to help the participants when some technical problems emerged in using laptops, the mapping tool, or the web-based collaboration environment.

Data Collection

The general investigative approach chosen for the study was exploratory multiple case research (Yin, 2003). A rich data set, collected from both cases, is described in Table 8.1.

Table 8.1. Data collected from each case

Data Source	*Description*	*Case 1*	*Case 2*
Teachers	Written scenario of the course design	X	X
	Written self-reflections during the course sent by email bi-weekly		X
	Interview after the course	X	
Students	Team interviews in the middle of the course; two teams with two and four students present	X	
	Written self-reflections after the course	X	X
Client representatives	Interviews after the course; clients of the two student teams interviewed	X	
Classroom observations	Observation of selected classroom meetings	X	X
Virtual working spaces	All database content: space structures, messages in discourse forums, announcements, uploaded files, concept maps, etc.	X	X

Data Analysis

The teachers' way of designing and structuring the activities in the case studies was, first, reconstructed through an exploratory analysis of the written self-reflections, observations, interviews and database content. Second, a detailed qualitative content analysis was conducted on the written self-reflections and transcribed interviews, classifying the central elements of the participant descriptions through the trialogical design principles. The excerpts of the textual data chosen for detailed analysis where those in which the participants described issues related to the pedagogical design or its outcomes in the courses. Each excerpt was then coded in the categories representing the six design principles. Other data, such as classroom observations and database content were used as complementary information to build an overview of the design features and practices in the courses.

RESULTS: ACTUALIZATION OF THE TRIALOGICAL DESIGN PRINCIPLES IN THE PEDAGOGICAL PRACTICES

In this section, results of analysis of the case studies are described to summarize how the educational units were designed from the trialogical learning perspective. For each design principle, the central aspects of the pedagogical design in the two cases are presented and scrutinized. The role of mediating technology is discussed under each DP when relevant as well as separately in the last DP.

DP1. Organizing Activities Around Shared Objects

In Case 1, the actual shared object was the multimedia product that the students designed and produced for a customer in project teams. The aim of working on a jointly developed, real product was fundamental to the overall organization of the activities of the students. However, individual self-reflections of the students revealed that in some teams the students did not actually get a real experience of collaboration over shared objects, because the tasks were divided between the participants, each member working quite separately with their own part of the design effort. In addition, the teacher gave some students the freedom to work alone with their own client and those students thus missed the collaborative working experience. Students used professional multimedia tools for producing the multimedia products, but these tools did not specifically include functions that would have enabled the joint elaboration of knowledge objects and the coordination of collaborative process between the team members and the clients.

The teacher fostered expert-like, collaborative project work practices by providing student teams with a project work structure and documentation templates to support the coordination and management of the design process. Both customers interviewed also emphasized these professional, systematic practices in collaborative project work. One intriguing observation was that the students did not seem to apprehend the meaning of project documentation in the same way as the teacher and the clients defined it. They did not use the documentation as practice coordinating the collaborative design process, because most teams produced only some of the documents, and even then usually behind schedule, after the product was already ready.

In Case 2, the shared object is less easy to define than in Case 1. The topic of the course, “Qualitative research methods” itself can be seen as performing the function of a shared, abstract, knowledge object. The procedure of collaboratively producing concept maps about the central concepts and approaches in the field of qualitative research methods created externalized representations of the main topic, working as mediating objects of collaborative activity to materialize an otherwise intangible shared object. Figures 8.1 and 8.2 contain examples of two concept maps (the first and the final version) created by one student pair during the seminar. The concept maps were produced by an advanced concept mapping tool that enabled their collaborative elaboration and sharing digitally through the web-based environment. However, each student’s own thesis was a vital individual object for the participants, while the conceptual mapping activity and discussions on presentations were meant to create a shared object for the participants during the course relating to the authentic, individual research object.

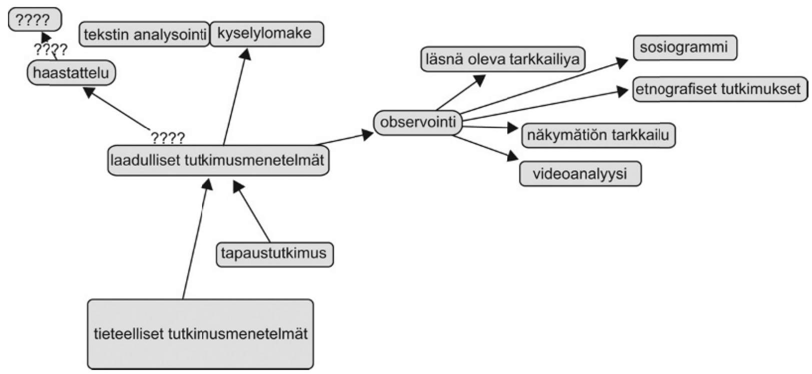


Figure 8.1. The first version of concept maps created by a student pair during the Qualitative Methods Seminar using CmapTools.

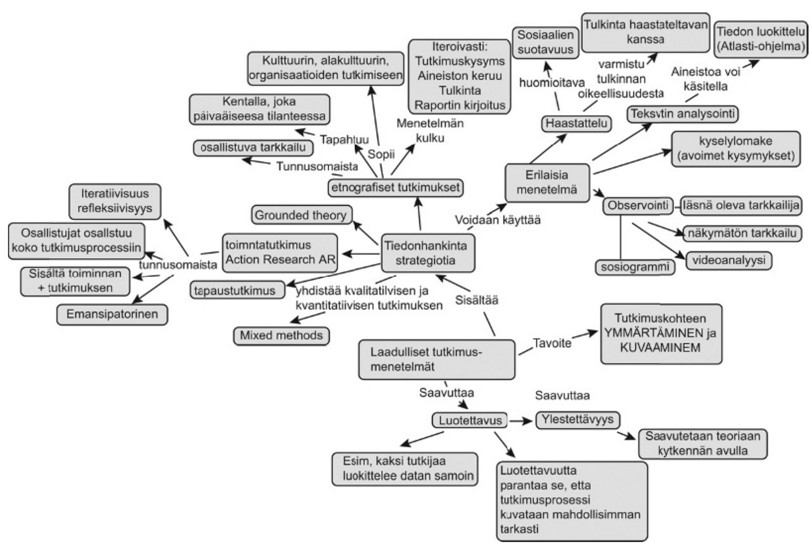


Figure 8.2. The last version of the same concept map as in Figure 8.1.

DP2. Supporting Interaction between Personal and Social Levels and Eliciting Individual and Collective Agency.

In Case 1, this DP was actualized by the team work structure, in which individual competences and efforts of the team members were combined to jointly produce the design product. The students had the freedom to choose the project work according to their own interests and situation as well as to organize the division of labour in the teams so that both their personal goals and the benefits of the team were realized simultaneously. The student assignments required both participation in the joint working process and its reporting and the production of individual learning logs concerning personal experiences. For the final course credits, the teacher took into account both team outcomes and personal learning logs. The following features of the challenging design project created conditions for developing epistemic agency: a complex authentic task, communication with clients about their demands, and the responsibility that the students collectively took for the progress and quality of the final product. One student was appointed as the project manager in each team, and the teams were obliged to constantly document the progress of the project. Some students reported that the distribution of responsibility, division of tasks and level of commitment did not work out satisfactorily in the group work, although the majority reported that they were also able to achieve their personal goals by collaboration with others. The technology used in the course did not support the coordination of individual and collaborative activities or product versions very well. The main role of the web-based environments was to offer a repository for the documents produced and announcements, instead of supporting the actual versioning and co-editing process.

In Case 2, the concept maps, created and modified during the meetings, can be stated to have mediated the interaction between individual and social levels because their creation required the students to share their ideas in pairs and integrate their personal conceptions with those of their partners. Similarly, student presentations were based on their individual methodological interests (e.g., "Ethnography"), but they shared their interests and understanding with others through oral presentations, and other students improved their own concept maps using new information gleaned from the presentations. The teacher promoted collaborative reflection by raising the problems of individual students in joint discussions. The maps and other products were also shared between all participants through the web-based environment. The seminar was meant to support the use of qualitative and mixed methods in the individual research projects, which highlighted their epistemic agency. The schedule of the course was based on the questions and problems introduced by the students, based on their own preparatory work, to benefit both their own research and all participants. According to the students' self-reports, this practice appeared to require more own initiatives than average courses. The seminar thus can be seen to have supported the students' epistemic agency more than conventional educational settings.

DP3. Fostering Long-term Processes of Knowledge Advancement

In Case 1, the students created the design products through iterative processes that converted their preliminary design ideas into implementable solutions. The essence of professional design activity is that the product is developed through successive, iterative cycles, which highlights this DP in the course. Especially because the design product was intended for authentic use in an external client organization, students had to seriously revise their knowledge products on the basis of the feedback from clients. This turned out to be a challenging task to execute in a short-term course. All teams were behind schedule and three teams had not finalized the product at the end of June. However, the teacher was flexible and allowed students to deliver project results after the course was officially over. According to the teacher, at the curriculum level there is continuity in systematic, long-term promotion of the project work expertise of students throughout the studies. The teacher had long-term contacts with many customers. The customers interviewed also mentioned a desire for long-term collaboration. In addition, the teacher created continuity within the institution by inviting a former student to give a lecture for the students about project work; this alumnus had done his diploma work about "lessons learned" in the projects carried out in previous years. It was a new element in the course, added based on the feedback from previous courses.

In Case 2, continuity across this individual seminar context was built into the basic idea of the setting by grounding the entire process in the participants' own research endeavour for their master's or doctoral thesis, which they had started before the seminar and would continue after it. The students were able to apply what they learned during the seminar in their ongoing personal research project. The setting had a *primary* emphasis on the personal, authentic research projects of students. Other course practices, such as participation in expert-like research discussions or collaborative work in creating presentations and conceptual models, served as *secondary*, instrumental and temporary elements supporting the long-term personal research task.

DP4. Emphasizing Development Through Transformation and Reflection between Various Forms of Knowledge and Practices

In Case 1, the entire ill-defined design task can be said to actualize this DP. In order to manage the work, the students had to use all their previous knowledge and skills in multimedia tools, design work and project work that they had learnt during their studies. They also had the opportunity to learn professional design work practices from the clients and experienced experts that they collaborated with. The teacher tried to foster the conceptualization of design knowledge and practices by the requirement to produce design documentation, presentations and self-reflection reports on both individual and team experiences. The teacher explained that the course was integrative in nature. He considered the role of reflective reporting to be important for the development of students, in addition to participation in actual project work. One client compared the course task to apprenticeship and emphasized importance of externalization and reflection to the students. Some students reported that they had, indeed, experienced and realized the multifaceted characteristics and challenges of design work through participating in the course.

Case 2 provided an opportunity for students to combine declarative knowledge (descriptive texts on qualitative research methods) and conceptual knowledge (core concepts related to research methods explicated in the concept maps) regarding qualitative research methods, as well as practical knowledge (examples of research studies presented by the teacher and the students) and tacit knowledge (collaborative solving of authentic problems related to the students' research through discussions). During the seminar meetings, the students were repeatedly engaged in discussions with each other on research problems and potentially relevant methodological solutions related to qualitative research. As a rule, the teacher promoted these discussions by raising methodological questions related to the research work presented. The students described the atmosphere of the course as warm, supportive, and encouraging discussion. In addition, the participants further implemented the methods in their authentic research projects, pursued parallel to the seminar, which according to the students' self-reflections was a very strong, positive feature of the course design.

DP5. Cross-fertilization of Various Knowledge Practices Across Communities and Institutions.

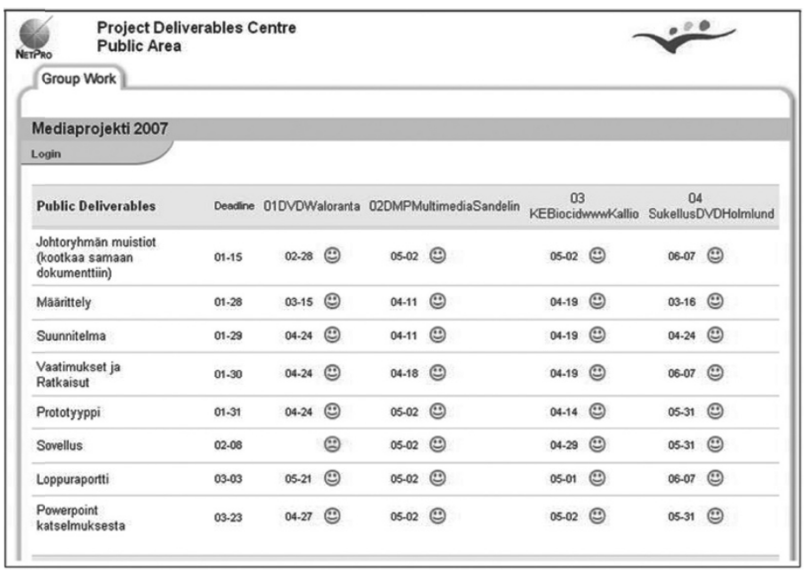
In Case 1, designing a product based on the authentic needs of customers and student collaboration directly with representatives of the customer organizations set facilitating conditions for cross-fertilization. The authentic work with real customers was the most important aspect that the teacher emphasised in his interview. It appears that real cross-fertilization emerged between all parties. The customers also reported that they learnt technical aspects and design practices from the collaboration with students, in addition to providing their expertise for student use. Predictably, the students reported that collaboration with clients was a crucial benefit of the course, as well as being challenging because it brought all the real-life problems into the project work, such as difficulty in understanding each other and sharing and explaining the domain knowledge, the customer's motivation and participation, and changes in the schedule, plans and resources. Inviting a former student to give a lecture about project work brought an additional element into the cross-fertilization practices of the course. The project work strategies and templates applied in the course were also adopted from professional project work practices.

The teacher himself had considerable know-how from the field through his 15 years' experience in organizing and supervising similar projects and collaborating with customers. One interesting aspect that emerged from the teacher's interview was the new challenges this type of customer-related practice creates for the teacher and the educational institution. The teacher has to maintain a large network of customers, be in contact with existing customers and seek new customers. The teacher then need time for organizing project allocation in the courses, and supervise the various projects that are going on. The teachers' situation had improved recently by sharing teaching responsibilities with another teacher. On one hand, this kind of networking and project supervision requires new skills of the teacher; on the other hand, it provides opportunities for learning and developing one's expertise.

In Case 2, a strong cross-fertilization element was the seminar teacher, who was not a full-time university teacher but a researcher who regularly used qualitative research methods in her own studies. She systematically shared her own experiences of research methods with the seminar participants by presenting authentic examples and modelling professional reasoning in her comments. The teacher distributed research articles for the students to familiarize them with ordinary research practices. In addition, the tasks in the seminar, such as giving presentations based on the participants' own research simulated typical practices of professional research communities. A visit by another educational researcher was conceived in the course scenario, and an expert lecture was included in previous iterations of the seminar. This visit did not occur during the seminar because practical obstacles. It would have strengthened opportunities for cross-fertilization, but was not critical to the seminar's success from the students' perspective.

DP6. Providing Flexible Tool Mediation

In Case 1, the students used professional multimedia tools for designing and producing the multimedia products. However, the focus in the KP-Lab project was on generic collaboration tools that enable the sharing of and managing joint objects and the collaborative process, but the role of such tools in the course was minimal. The OVI portal was used only for delivering documents and instructions between the teacher and the students. The NetPro system enabled the sharing of final project documents between the project teams, but it was used for keeping track of the formal documentation for reporting the project progress to the teacher, not for elaboration of, commenting on or editing of the design objects (see Figure 8.3). Project teams mainly used e-mail for their internal communication. One team had themselves founded a web-portal for their project work and another team shared the developed video product versions with the client through web-links, solutions appreciated by the clients of those teams. In the interview, the teacher especially complained that the sharing of the design process with the clients virtually was not possible because of the lack of extranet services at the institution.



Public Deliverables	Deadline	01DVDWaloranta	02DMPMultimediaSandelin	03 KEBiocidwwwKallio	04 SukellusDVDHolmlund
Johtoryhmän muistiot (kootkaa samaan dokumenttiin)	01-15	02-28	05-02	05-02	06-07
Määrittely	01-28	03-15	04-11	04-19	03-16
Suunnitelma	01-29	04-24	04-11	04-19	04-24
Vaatimukset ja Ratkaisut	01-30	04-24	04-18	04-19	06-07
Prototyyppi	01-31	04-24	05-02	04-14	05-31
Sovellus	02-08		05-02	04-29	05-31
Loppuraportti	03-03	05-21	05-02	05-01	06-07
Powerpoint katselmuksesta	03-23	04-27	05-02	05-02	05-31

Figure 8.3. A view of the document repository in the Media Project course, listing project documents of four teams with submission dates (e.g., Management group memo, Definition, Plan, Requirements and solutions, etc.).

In Case 2, CMapTools was used for individual and collaborative modelling of the subject domain content through concept maps; this tool has very sophisticated functions to support such practices (see Figure 8.1 above). FLE3 mediated the virtual discussions of the students and performed the function of a shared repository for distributed materials. Most students found CMapTools were relatively easy and flexible to use. Some found FLE3 difficult to use and felt that not enough help was available for sorting out problems (e.g., to create links on a discussion board), even though there was a technical assistant present at the seminar meetings. Some students did not understand the purpose of FLE3 in the course, and therefore did not use it very actively. Some students did not understand the idea of sharing background materials and did not know where to insert them in the system. Students also had laptops as tools during the seminar meetings. This caused some problems for those students who were not familiar with the login and file management practices of the university. The findings appear to imply that the implementation of two different technical applications and laptop computers (with the university file management system) was too challenging an objective given the relatively short duration of the seminar. The saving and sharing of knowledge products between the participants was constricted by the complexity of the technical infrastructure and the difficulties in integrating the use of several tools.

DISCUSSION

Evaluating the Pedagogical Designs

The first research question focussed on pedagogical design of the educational units, and suggesting recommendations for developing the designs further. According to the analysis, the trialogical design principles were realized with differing characteristics and emphasis in the two cases investigated.

Strong aspects of the pedagogical practices of Case 1 were the central role of a shared design object (DP1), the transformation and reflection between various forms of knowledge and practices (DP4) and strong cross-fertilization between students and clients in the design activities (DP5). The design products that the students produced for the clients had an important role in the collaborative work as they motivated, directed and embodied the shared efforts of the participants. The design assignment challenged students to relate their theoretical knowledge to practical design problems, to develop their project work skills and apply them in authentic work situations. The complex, ill-defined task required the integration of knowledge from various fields, such as design methods and theories as well as project management and communication. The collaborative design processes involved collaboration between students within the group, and with teachers, design experts and representatives from customer organizations, and also bilateral cross-fertilization between the involved parties emerged.

The combining of personal and collaborative interests and agency (DP2) could have been more carefully supported and supervised by the teacher. The principle of promoting long-term knowledge creation processes (DP3) is a two-sided issue concerning this course. It was built on student competences accumulated in previous studies, and the fundamental design activity was developing the product through successive, iterative cycles. Because the design product was intended for authentic use in an external client organization, students revised their products seriously on the basis of the feedback from clients. However, the course period turned out to be too short for such a challenging assignment. This is a frequent conflict between heuristic aim of fostering long-term processes and practical limitations of the institutional curriculum structure with short-term courses. Such flexibility in timetables is usually not allowed in real working life, however. The role of the mediating tools (DP6) was the weakest aspect of the course design, because the groupware technology was only used as a repository for final products and e-mail was the main tool for asynchronous communication. More advanced support for coordinating and advancing the collaborative and iterative design work, including with external stakeholders, could have been provided by the tools.

In Case 2, the seminar practices in particular promoted the combination of individual and social levels (DP2), long-term engagement in the knowledge creation processes (DP3), as well as transformation between various forms of knowledge and practices (DP4). The creation of and discussions concerning conceptual models and presentations required the students to share their ideas and test the joint models against their own understanding. They also received ideas and recommendations for their personal research projects, which they were continuing after the seminar. Due to the complexity of the topic, students had to weigh and integrate knowledge from various sources and domains in order to come up with enough knowledge to apply the methods for their practical research goals.

The role of an actual shared object (DP1) was not so strong in the seminar practices, because the shared objects (concept maps and presentations) were not meant as ends in themselves but as a support to more overarching individual goals. However, this aspect is difficult to change when the main aim of the seminar is to support the individual research endeavours of each student, and offer a temporary research community and expert support for this. In this sense, the strong emphasis on individual achievements in a higher education curriculum creates barriers to changing the pedagogical practices. The elements of cross-fertilization (DP5) could be strengthened in the seminar by acquainting participants with authentic research practices of other professional researchers beside the seminar teacher. The use of multiple, separate technological application in the seminar did not succeed in providing flexible tools for mediating and coordinating shared knowledge creation processes (DP6). The visual modelling tool was hard to integrate in a groupware solution, making it difficult to share models and background materials. The use of multiple tools resulted in increased training needs for the students. In more recent iterations of the seminar, separate tools have been replaced by an integrated tool, which appears as more appropriate support to combine knowledge creation and collaboration activities (Kosonen, Ilomäki & Lakkala, 2010).

Usefulness of the Trialogical Design Principles for Examining Pedagogical Practices

The second research question was whether the set of trialogical design principles provides a useful tool for assessing pedagogical practices. Based on analysis of the case studies, the theoretically oriented design principles provided a usable framework that enabled description of two different pedagogical units through uniform concepts. The framework helped to reveal aspects that could be improved in the courses on the basis of the trialogical approach to learning. However, some design principles seemed ambiguous in being applied in the analysis of the pedagogical units, which resulted in the following suggestions for specifying them.

Concerning DP1, the various meanings and roles that a shared object could have in educational process needs to be explicated. This could mean an abstract topic or phenomenon that the group is trying to understand; an actual artefact in which the immaterial object is manifested, produced by the group with tools; or an even more remote objective that is a motive driving the whole activity or reason to work on the shared object. The connection between an object shared by the group and an object of individual students should be clarified. In Case 1 of the present study, the design product represented a very strong shared object for the team members, but the shared objects in Case 2 (concept maps and presentations) served as secondary, supportive means for the more important personal object for advancing one's own research. Even if the object is "immaterial" (such as understanding a topic, improving working practices, or designing an event or service), the idea of trialogical learning emphasize that activities of members are organized around production of mediational material artefacts, e.g., plans, reports or visual models. The joint work on this kind of artefact allows collaborators to externalise their ideas, evolving knowledge and understanding as well as learning to work with them collaboratively, and thus helping the mediation of collaborative epistemic efforts.

Concerning DP2, the cases investigated demonstrated how challenging it is to find systematic ways to support and supervise student engagement in a collaborative endeavour, simultaneously taking into account individual interests and contributions. This would require explicit criteria, rules and models for structuring the collaborative activities, appropriate functionality in collaboration tools as well as close supervision and guidance by the teacher.

As mentioned already, the notion of "long-term knowledge advancement" (DP3) seems somewhat ambiguous and need further clarification. There are various aspects of this. It might mean the duration of the collaborative knowledge creation process, including across the educational setting as in Case 2, or the iterative, sustained pursuit of creating novel knowledge artefacts even if for a shorter time, as in Case 1. An important aspect is the extent to which the practices support the cumulative use of existing societal knowledge and the re-usability of the knowledge artefacts in the future. This aspect was especially apparent in Case 1. Another aspect concerns the individual learner's opportunity to expand his or her personal expertise and to pursue personal goals across separate educational settings. This aspect was crucial in Case 2.

Promoting the transformation and integration of various forms of knowledge and practices (DP4) seems to be an inbuilt feature of pedagogical designs based on complex, ill-defined knowledge creation work, as it was in both the cases investigated. The importance of this DP is probably generally well understood among educational practitioners emphasising this kind of knowledge work. However, deliberate reflection is a practice not demonstrated often enough in actual practices, let alone implemented systematically and throughout the process. Reflective practices should be built into the entire course design, which was very obvious in Case 2 but less so in Case 1. It should be emphasized that this DP means not only final reflection at the end of the process, and not only individual self-reflection of one's own learning, but collaborative, iterative reflection of the joint process, knowledge practices and products throughout the process, in order to improve the practices "along the way".

Concerning DP5, the analysis of the case studies exemplified many different forms cross-fertilization may take in educational practice. For instance, in Case 1 there was strong cross-fertilization of expertise and practices between the students and representatives of customer organizations. Another mode of cross-fertilization in the course was to provide students with conceptual and material tools, like project work models and document templates that mediated true professional practices in project work. In Case 2, the cross-fertilization included apprenticeship-type collaboration between an expert and novice researchers in the same institution, the expert having the role of sharing experiences and examples, as well as modelling professional reasoning strategies in solving methodological problems.

Relating to DP6, the study addressed how important it is that technology not be marginalized but be regarded as a crucial mediating element both affecting and affording all elements of knowledge practices in a fluent way. In the cases investigated, existing technologies did not provide very good support for the practices. Although individual tools might have been useful for a special practice, the products were hard to use in other systems or share and elaborate collaboratively, making it difficult to exchange materials or further revise the knowledge objects produced together. This experience highlights an obvious need to develop tools that provide better affordances for collaborative knowledge practices in a way that is flexible and versatile as well as easy to use in various educational contexts and with novice users. The KPE platform, produced after the present study in the KP-Lab project, has been an effort to create an integrated system to actualize this design principle better (Bauters et al., this volume, and Lakkala et al., 2009).

CONCLUSIONS

The trialogical design principles provide heuristic guidelines for educational practitioners and others involved in designing and promoting advanced pedagogical practices and related competences. Rather than just listing examples for operationalizing the design principles in practice, it might be useful to try specifying some main levels or dimensions through which the instances of design principles could be categorized and analysed; for example, specifying weak or strong forms of the trialogical approach. The domain, context, and education goals of each setting affect the emphases that specific design principles have in each case (Kali et al., 2009). The principles should not be followed strictly or normatively; every educational setting has its realities that affect the opportunity to transform existing practices, but the design principles can be one 'vehicle for change and innovation'.

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KLAS KARLGREN

9. TRIALOGICAL DESIGN PRINCIPLES AS INSPIRATION FOR DESIGNING KNOWLEDGE PRACTICES FOR MEDICAL SIMULATION TRAINING

INTRODUCTION

This chapter discusses introduction of the trialogical approach to simulation training courses for medical teams involved in neonatal resuscitation. We analysed and developed knowledge practices in a tradition-laden educational context, which has not viewed itself as promoting learners' 'knowledge-practices' or 'knowledge creation'. The overarching educational objective was to support medical teams in improving their coordination, leadership, teamwork, and communication in order to contribute to patient safety. Paavola et al. suggest the usefulness of a third metaphor of learning, the *knowledge creation* metaphor, to shed light on cases of learning which involve "collaborative, systematic development of common objects of activity" (Paavola & Hakkarainen, 2005). They argue that a conception of learning adequate for a knowledge society not only addresses transmission of existing knowledge or construction of knowledge by individual students (acquisition metaphor), and neither is it enough to emphasize various processes of socialization and growing up to communities and their values (participation metaphor). The third metaphor helps us to elicit and understand processes of knowledge advancement that are important in a knowledge society. The approach seeks to address the importance of generating new ideas and conceptual knowledge as well as examining learning in terms of creating social structures and collaborative processes that support knowledge advancement. The approach is 'trialogical' because its emphasis is not only on individuals or communities, but on how people collaboratively develop mediating artefacts to consciously advance knowledge, discovery and innovation (Paavola & Hakkarainen, 2005).

Medical education has a strong tradition of pedagogical approaches which could be described by the two earlier metaphors rather than stressing how learners create their knowledge collaboratively. The courses in the present case were initially far from 'trialogical' and did not display the features and practices characterized as trialogical approaches to learning activities. Transforming the course in a more trialogical direction would be beneficial and would avoid some existing problems. Tools and practices, and specific knowledge creation activities have been designed and promoted in this case. How the 'trialogical' approach and its third metaphor of learning influenced the design of the educational setting and tools will be discussed but, first, the domain is presented below.

A. Moen, A. I. Mørch, S. Paavola (Eds.), Collaborative Knowledge Creation: Practices, Tools, Concepts, 163–184.

THE DOMAIN: COMMUNICATION AND TEAMWORK IN MEDICAL TEAMS

Critical care contexts such as the emergency room, the operating theatre, the intensive care unit, or the delivery room place high requirements on medical teams. Because of the dynamic nature of these contexts, clear and efficient teamwork and communication are decisive. Improving teamwork and communication may help reduce or better manage errors (Thomas, Sexton & Helmreich, 2004) and avoid deaths (Risser et al., 1999). Neonatal resuscitation is one of the most frequently practised forms of acute resuscitation (Carbine, Finer, Knodel & Rich, 2000) and the resuscitation teams are interdisciplinary and typically loosely formed, since resuscitation may be needed at short and unexpected notice: typically, not all team members are present from the beginning (e.g., paediatricians, anaesthesiologists and other specialists may be summoned) and do not arrive at the same time, making information sharing (e.g., assessment of the patient's status) complicated. Moreover, the team members may not have met each other before and do not have explicitly assigned roles as, for example, members of an emergency room team do. Clear communication is, therefore, of the utmost importance for interdisciplinary teams to work efficiently and is crucial for avoiding adverse events. Failure of communication contributes to error (Helmreich & Merritt, 1998), therefore improvements in teamwork and communication can significantly enhance the quality of emergency care (Bergs, Rutten, Tadros, Krijnen & Schipper, 2005).

Moreover, clear leadership is crucial for a medical team to work efficiently. Team members need to understand how decisions are made within the group, what resources are needed and how they are to be utilized, and how members new to the situation are integrated into the group, while the leadership role includes the explanation of the collective aims and requirements of resuscitation (Cooper & Wakelam, 1999). Resuscitations under a clearly-identifiable trauma team leader have been found to enhance trauma resuscitation performance (Hoff, Reilly, Rotondo, DiGiacomo & Schwab, 1997). However, clear leadership is often lacking in neonatal resuscitation. Thomas and colleagues observed that neonatal resuscitations usually did not have a clear leader, either in deed or word, and leadership roles were fluid and highly dependent upon team composition and experience level (Thomas et al., 2004). Unfortunately, experience does not seem to be a guarantee for developing efficient leadership. Cooper and Wakelam (1999) discovered that some leaders had very low performance ratings despite a great deal of experience: attending more than 20 cardiac arrests over the previous year did not make team leaders more effective[1] leaders. Superb individual clinical skills do not guarantee effective team performance in care, and effective teamwork does not arise spontaneously but, rather, requires specific skill development and practice and must be learned through specific training (Risser et al., 1999). Making observations of communication breakdowns in medical teams is far from a trivial task and even experienced and trained observers may have difficulties in reaching agreement on whether or not communication failures occur in operating rooms (Lingard, Regehr, Espin & Whyte, 2006). To improve team performance, teams need to be able to analyse their work. Yet this can be very difficult. A challenge is that even very experienced practitioners may lack a language and routines for analysing the quality of teamwork and communication, making improvement difficult. The challenge is even greater considering the different professional backgrounds and the different expectations which accompany these.

Simulation Training in Medicine

Simulation training courses in medicine often address several of the challenges discussed above. The case discussed here presents specific courses for training inter-professional resuscitation teams, addressing medical work, teamwork and communication with a particular emphasis on the clarity of leadership. The courses are given at the Center for Education in Pediatric Simulators (CEPS) at the Stockholm South General Hospital and are arranged by Karolinska Institutet. The courses are intensive one-day courses starting with lectures and followed by simulations and debriefing and feedback sessions. The participants have different professional backgrounds and are, typically, paediatricians, anaesthesiologists, obstetricians, nurses, and midwives. In the simulations, the course participants work in teams to solve complex, authentic cases: the medical teams provide newborns (a small manikin) arriving from the delivery room with intensive care. Immediately after each simulation, the teams are debriefed and video recordings of the simulations are analysed together with the instructors. This procedure is iterated several times during the course, see Figure 9.1.

Figure 9.1. Simulations, debriefing and watching video recordings iteratively.

The emphasis is partly on learning the medical guidelines, resuscitation procedures, and equipment, and partly on the importance of well-functioning teams with good communication is also emphasized. The simulations are video-recorded and the recordings are reviewed and discussed in facilitator-led debriefing sessions following the simulations. During these sessions the teamwork is discussed with the goal of finding ways to improve the teamwork and communication of the team. One potential problem is that participants can become confused by all the different issues brought up by the instructors, as illustrated by this quote from a participating paediatrician exclaiming: '*I would like there to be only a few, maybe four, important things to focus on and which are returned to each time…*'. This quote shows the risk of participants becoming confused about what they need to improve and a need for support and structure. Since learners cannot improve unless they know where improvement is necessary and how the improvements may be made (Mackway-Jones & Walker, 1998), we will discuss how we have attempted to support participants in analysing their work.

THE PROBLEM AND OBJECTIVE

The problems motivating this work are a number of tightly intertwined problems and challenges. Identifying and analysing critical teamwork incidents is difficult. Participants in simulation training courses have in general little or no training in evaluating the quality of teamwork and communication in medical teams. Even fewer have active knowledge of models and concepts that could structure their activities of describing, analysing or assessing medical teamwork and communication. In many cases there is an unawareness of gaps in the teams' knowledge of efficient teamwork and communication. While the course participants usually recognize and accept analyses made by course instructors, they do not actively engage in analyses on their own and are unlikely to engage in such analysing after the course. Moreover, because of the slightly abstract character of the subject matter, it risks being taken for granted without repercussions on actual practice. Furthermore, some participants are more active in making observations and analyses while others remain passive during debriefings.

The course participants do not have a clear and established practice for analysing teamwork and communication in neonatal resuscitation. From the perspective of the trialogical approach, this is the 'shared object' that is largely missing. The objective of this trial has been to modify this initially un-trialogical case into a more trialogical one by creating and developing knowledge practices with inspiration from the trialogical design principles. The objective was to create, develop, and support knowledge practices concerning medical teamwork analysis for the medical simulation training environment and to extend knowledge about such design attempts using the trialogical approach as a starting point in a concrete case. The aim was to develop the course setting in such a way that the participants became engaged in collaboratively developing the teams' analysis practices.

DESIGNING CONDITIONS FOR KNOWLEDGE PRACTICES

Given the described situation, we chose to emphasize knowledge practices, which, traditionally, do not receive much attention in medical and health education.

Inspiration from Trialogical Design Principles

Some of the design principles (DPs) that inspired this case are brought up earlier in this collection (cf. Lakkala et al, this volume). They helped to address a number of the challenges mentioned above, and, if handled well, would improve the courses; how they have been related to this specific context is discussed in the next section. The design considerations are later discussed, connecting the design solutions to problems they attempt to (re)solve in terms of design patterns.

DP1. Organizing activities around shared objects. A central idea of trialogical learning is that work and learning are organized around developing shared knowledge objects. Lack of the obvious 'shared object' has been part of the problem: the course participants typically did not have a shared understanding of the teamwork events and incidents nor did they engage in the knowledge practices we wanted to promote. Developing an educational context is a matter of choosing which activities should be promoted. After several iterations of modifying the course it became more and more clear that the analysing during the debriefings played a key role in the participants' development. Therefore, we chose to view the activity of analysing as the shared object of the case which we have attempted to support. The focus was thus on the process of analysing teamwork and communication as displayed by the teams participating in simulations.

DP2. Supporting interaction between personal and social levels and eliciting individual and collective agency. People integrate their own personal work and group work into developing shared objects, combining participants' expertise and contribution into the shared achievement. Not all course participants participate as actively in analysis during debriefings, and the teams are not so good at utilizing the whole team's observations and points of view. Some will not speak out about their opinion. There tends to be quite a bit of uncritical agreement during the debriefings, and some individuals may dominate while others are not heard. Inspired by this design principle, we have tried out different combinations of individual and collaborative tasks to support the interaction between individual team members' analysis and the collaborative analysis, discussed below.

DP3. Fostering long-term processes of knowledge advancement. Trialogical learning requires sustained, focused work on topics of interest**.** This design principle highlights a set of challenges concerning the objective of supporting practices beyond duration of the course. As course participants may lack a coherent theoretical framework or full awareness of their knowledge gaps, they may fail to continue analysing on their own after they have completed the course. To promote long-term changes in participants' practices, the course needed to provide its participants with tools and practices they could take with them to the clinics.

DP4. 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-upon, conceptualized and transformed during the process**.** The importance of externalizing one's thinking during critical care is already heavily emphasized in the simulation courses: team leaders and others are encouraged to think aloud, whenever planning, summarizing and evaluating. Such externalization can inform the entire team, which then can take part in activities such as decision-making and evaluations collaboratively. The courses also combine practical engagement and debriefings. Nevertheless, a challenge is that many of the theoretical ideas brought up about teamwork and communication in the course are, at first sight, considered self-evident and may, therefore, not lead to any changes in practice – there is simply total agreement but little change in actual behaviour. The theoretical ideas needed to be connected more tightly to and transformed into practice. We have chosen to let this design principle, with its focus on transformation and reflection, inspire us by creating novel knowledge practices discussed below.

The word 'inspired' is used to reflect the role or status of the design principles and how they were used in this case. A choice was made to emphasize a subset of the design principles by picking those viewed as most viable for the current case and therefore most likely to produce desirable effects. The chosen principles were viewed as the most valuable ones for this particular case but other choices could also have been conceivable. Moreover, the design principles have a quite general character and do not, in a concrete way, determine or specify the design of an intervention in a new context, like simulation training of teamwork. Considerable work was needed to construct realistic ways of implementing the ideas described by the design principles. This chapter describes one way, though, naturally, other ways are possible. Another related point could be made concerning the status of the design principles; the heading of this section is called 'designing conditions for knowledge practices'. Knowledge practices cannot be *designed* in a definite way simply because course participants as human beings cannot be controlled in a deterministic way. Focus is therefore on creating conditions that are believed to support and encourage certain knowledge practices.

DESIGNING A CONCEPTUAL MODEL OF TEAMWORK AND COMMUNICATION

There was a need to support the medical teams in assessing and analysing their performance during debriefings. As mentioned, the participants lacked a shared language, were overwhelmed by the many issues from time to time, had knowledge gaps and were faced with other challenges. Therefore it was decided that, in order for the teams to be able to establish and develop new knowledge practices, some support was needed in getting them started and in structuring the practices. As the teams already had a number of common conceptual tools used continuously during the medical work, we decided to create a conceptual tool inspired by an existing scoring system well known by the teams, namely the Apgar system. The Apgar system is an established test to evaluate a newborn's physical condition and consists of five factors scored on a scale. In analogy, we developed a conceptual model for the analysing of teamwork and communication in neonatal resuscitation teams that could be used in the debriefing sessions. The APCER model, or the 'TeamApgar', covers key issues concerning efficient medical teamwork and team communication (Karlgren, 2007; Karlgren, Dahlström, Lonka & Ponzer, 2007). The 'TeamApgar' focuses on five easily observable typical team leader and team member behaviours and is a scoring of the medical team's 'status'. APCER is an acronym for the headings of the five rows where each one concretizes a behaviour for the team leader (left column) and a corresponding behaviour for all team members (right column), (see Table 9.1 below).

Table 9.1. The conceptual model APCER, or 'TeamApgar'

Team Leader	*Score (0, 1 or 2)*	*Team Members*
Takes / gives cap	**A**ssigned Roles	Presents oneself
Plans shared by thinking aloud	**P**lan	Prepares, one step ahead
Clear / directed orders	**C**ommunication	Confirms
Evaluates continuously	**E**valuation	Reacts and offers advice
Calls for help in time	**R**esources	Draws attention to needs, supports others

A goal was that the model should be concrete, easy to grasp and concern observable behaviours, which are important factors for successful team behaviour in this context. The model thus provides behaviours which are 'prototypical' behaviours signalling well-functioning teams rather than a full assessment of all aspects of teamwork and communication. Compared to other existing models, APCER was made simpler, with fewer items and more concrete behaviours, thereby not presupposing training for its use.

Figure 9.2. Early paper prototype versions of the APCER model.

The objective for APCER was to explicate key issues, provide a shared conceptual tool and language for discussions during debriefings, and when used to assess team performance provide participants concrete goals to focus on for improving performance. The teams used the model during debriefings and assessed their own performance with game-like scoring. A score which resembles the Apgar score was devised awarding 2 points for every correct behaviour, 1 point for delayed or inadequate behaviours, and zero points for omitted behaviours. The primary focus has been to create a model that works for reflection, discussion, and feedback during debriefing sessions (see Figure 9.2). The scoring is, therefore, mostly a motivating feature rather than an attempt to make definite assessments. The model contributes by making other participants' views and observations public, and makes it easier for the participants to make use of each participant's observations when analysing collaboratively.

To give individuals a chance to reflect on what just happened, the model was used individually immediately after each simulation and served as a starting point for the collaborative analyses during the debriefings. Later, the participants convened for common discussions and the debriefings were ended by giving the course participants the task of agreeing on a score requiring discussion and negotiation of the different viewpoints of the participants. The use of the APCER model during the debriefings was studied in detail and is discussed next.

Interaction Analysis of APCER use in Debriefings

We used interaction analysis (Jordan & Henderson, 1995) of video recordings as the method of analysis to investigate the development of the knowledge practices during the courses. The analyses had a focus on the participants' interaction and talk with each another and with instructors, as well as talk and interaction in relation to the categories of the APCER model and other tools in the environment (Karlgren, Dahlström & Ponzer, 2009; Karlgren & Damşa, 2009; Sins & Karlgren, 2009). During the debriefings the course participants watch and analyse the video recordings of the simulations that they have just taken part in. The analysing is done together with the instructors. The video-recorded sessions were transcribed for analysis. The interaction analysis has had a special focus on dialogues between participants and between participants and instructors as well as their use of the (conceptual) artefacts. Moreover, the participants' roles in the team (leader or member), professional roles (profession) and roles in the simulations (participant, observer) were given special attention in the interaction analysis. Of interest have been the kinds of analyses that were created in the debriefing discussions and how these developed during courses. We present three fragments of the interaction analysis that were selected to illustrate how the course participants discussed APCER categories. The transcripts have been translated into English by the author.

Some typical recurrent trends have been discerned in the investigation of the debriefings of the many courses that have been studied and some of these are brought up here. For instance, one such trend is that the initial analyses made by the participants in the beginning of the courses were often not so well structured and therefore rather imprecise. The participants also tended to be overly critical of their own performance but, typically, uncritical and even overly positive about any achievements made by the rest of the team. More seriously, they tended to overlook serious mistakes and safety-critical behaviours, revealing unawareness of many critical issues regarding teamwork in critical care. Later in the courses, when the participants began agreeing on a shared conceptual framework and terminology, typical changes took place. The team members started using and referring explicitly to common concepts (Fig 9.3). It appeared as if this contributed to problematic issues being overlooked less and addressed more often.

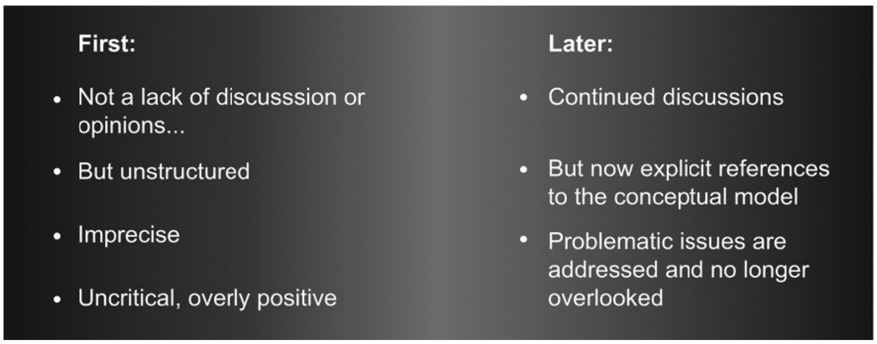

Figure 9.3. Typical characteristics in the analysis activities.

The excerpt below is from a debriefing following the first simulation of a team which has just had a number of very serious problems: the team failed to ventilate the patient properly; they did not call for help in time; and several of the team members did not offer suggestions that could have helped the team, even though they were thinking of these suggestions.

1. **Obstetrician:** Well, so I had the cap … and it was a little strang– … because it felt like … you (midwife) stood there, at the head-end [of the bed][a]–
2. **Midwife:** Yes–
3. **Anesthesiologist:** But that was good–
4. **Obstetrician:** Because it worked pretty well there… because you were doing …
5. **Midwife:** Yeah, but I felt that ... nothing happened ... I didn't know what to do!
6. **Obstetrician:** Yeah, but we did ... We shifted to–
7. **Nurse2:** Yeah, but it worked
8. **Obstetrician:** Yeah, but then I on the other hand had the cap and said that we should shift … and then we changed to the bag valve mask. So that was really good.

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[a] (Hyphens [–] indicate an abrupt cut-off or self-interruption of the word or sound in progress)

9. **Anesthesiologist:** That, that was good!
10. **Pediatrician:** Well ventilating went well which was really good ... and it was sort of ... and it worked ... rather well.
11. **Obstetrician:** We listened and ventilated … listened to the heart. We called for help a bit late, after a minute when we still had the same, should have called a bit earlier.

Despite all the problems listed before the excerpt, the dialogue illustrates a typical, overly positive attitude among the team members who are at the beginning of the course and obviously unaware of many of the serious problems (lines 3, 4, 7–10). The team seems quite pleased with its performance. Some self-criticism is expressed by one person (line 5). At the end of the excerpt (line 11) some questioning of the team's performance is displayed. The excerpt showed that the team overlooked many grave problems at the beginning of the course before the teams had established knowledge practices, which address the potential problems. Later, when the team analyse the videotape with assistance from the instructors, they will become aware of the problems and realize that they should have called for help immediately to save valuable seconds. Later in the course, the same kinds of discussions continued, but with the difference that, at some points of time, explicit references were made to the categories in the APCER model.

The next excerpt below is from after the third simulation. During a discussion about the Caesarean section in the preceding simulation the anaesthesiologist shifts the topic and refers explicitly to an APCER category:

1. **Anesthesiologist:** '*Presents oneself*' – did anyone do that? [referring to an APCER category]
2. **Pediatrician:** I don't think anyone did!–
3. **Nurse:** Naw–
4. **Anesthesiologist:** … and everyone was presupposing … that there should be zero – *silence* – while ...*
5. **Nurse:** Yeah

Since the categories here are on a very concrete level, there is little room for interpretation as to whether the desired behaviour was displayed or not, making it obvious that the team did not meet the requirements of this particular APCER category "Assign Roles" (everyone is instructed to present themselves with name and profession upon arrival so the rest of the team becomes aware of what new resources are available). This makes it less likely that potential problems are overlooked, which is common early on in the courses as illustrated by the first excerpt. The paediatrician and nurse have noted that nobody presented themself (lines 2 and 3), the anaesthesiologist suggests an explanation why; presenting oneself was experienced as conflicting with the need for silence when listening to heart and lung sounds (line 4). This excerpt thus illustrates the first steps of the team towards analysing what happened in the teamwork; they identify a problem or incident (line 2 and 3) and they then begin discussing (line 4) why they did not live up to the agreed-upon goals of the team, thereby giving a reason for and possible explanation to the incident.

The last excerpt, below, shows a part of a dialogue towards the end of the course where a problem is identified and the team finds explanations to it but here they carry on their analysis one step further.

1. **Paediatrician:** Yes, there is a delay with the (paper) note and all
2. **Instructor:** Ye-es. We see that. And why did this happen then? How can this come to take place?
   – *Silence*
3. **Paediatrician:** Because I was distracted by the note of course, otherwise …
4. **Instructor:** Can this happen in real life do you think?
5. **Several at once:** Yes
6. **Several at once:** Absolutely
7. **Anaesthesiologist:** The midwife coming in with the paper maybe checks what is going on and does not put it in your fist; it's a bit like, is this the right occasion?
8. **Paediatrician:** …or I should have said: 'Wait a second' and put up my hand to illustrate.
9. **Anaesthesiologist:** Yes

On line 1 of the excerpt above, the team has identified a problem and some questioning from the instructor leads to an explanation being offered as to how the problem could occur (3). Eventually, different team members suggest two different solutions to how the team could behave to avoid the identified problem (7 and 8). At this point the team has developed their analysing practices and soon manage, in just a few interactions, to identify a problem, generate an explanation and suggest two different ideas about how to handle the problem if faced by it in the future.

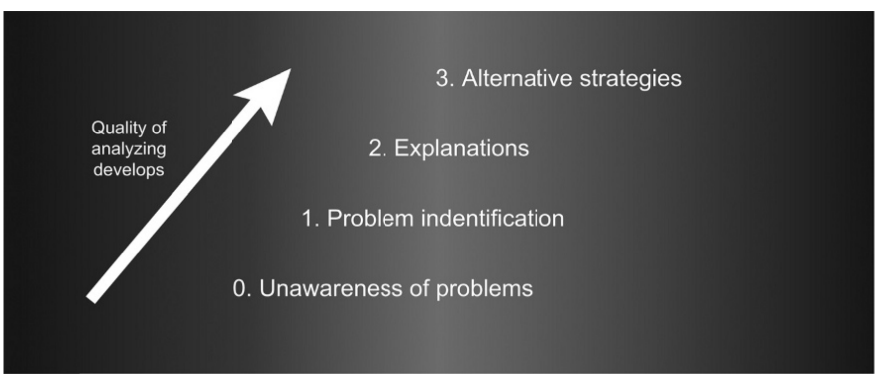

Figure 9.4. Typical trajectory of the knowledge practice of analyzing a debriefing sessions.

The excerpts illustrate some typical changes in the approach of the teams during their analysing. The excerpts provide empirical examples of how the participants relate to the introduction of the APCER model; the concrete categories of the model directed the discussions during the debriefings to highlight important behaviours in the discussions (as in excerpt 2) which otherwise risked being neglected. Further analysis of the debriefings has shown that the quality of the analysing carried out by the participants develops during the courses. The teams' analysing typically develops through a number of phases. Initially, the participants often lack awareness of the importance of clear and efficient medical teamwork, problems occurring in their own teams and the body of research and theory in the field on such issues (Figure 9.4). The first excerpt is an example of this. Having taken part in some simulation training and receiving feedback from experienced instructors typically leads to (1) course participants becoming aware of and beginning to identify problems that take place. Often these are focused on in a rather unconstructive way and frequently participants will blame themselves for causing them. While they may be highly motivated to perform better and to avoid the problem in new simulations, they often do not create sufficient explanations of why the problems occurred in the first place, making it difficult to create strategies to avoid the difficulties. Later, participants begin (2) constructing explanations to the problems. The second excerpt above displays how the team notices a 'problem' and a first attempt to explain why it occurred. Eventually the teams will also (3) suggest alternative behaviours, which may resolve or avoid a particular kind of problem, as in the third excerpt. The third level in figure 9.4, suggesting alternative strategies is when the teams ultimately create new knowledge, even though the preceding levels are usually needed. The trajectory is not a simple step-by-step development in all cases, but represents typically recurring phases. Support from the instructors, the conceptual tools and repeated practice in taking part in analysing activities appeared to support the development.

OBSERVATIONS OF THE PRINCIPLES CAPTURED AS DESIGN PATTERNS

What can be learned from the use of the design principles? It has been claimed above that the design principles were used as an inspiration for this case. While there is not a simple relationship between design principles and design solutions, some of the resulting solutions could be discussed. In general, design principles do not explain *why* or *when* they should be applied and have, therefore, come under criticism on several counts (Borchers, 2000; Mahemoff & Johnston, 1998; Pemberton, 2000):

- for their difficulty of interpretation
- for being too simplistic
- for the excessive effort required to find relevant sections
- for requiring sophisticated interpretation
- for risks of neglecting or misinterpreting advice and guidelines; etc.).

As an attempt to capture successful practices in this case, educational design patterns were therefore created.

A design pattern is a three-part rule, which expresses a relation between a certain *context*, a *problem*, and a *solution* (Alexander, 1979). The design pattern format used here is a version of Alexander's original format (Alexander, 1977). It is slightly simplified and modified to more clearly highlight the three most important things in a design pattern; the problem, solution and context:

Title

Introduction
1. Problem and forces at play summarizing the essence of the problem. 2. Solution 3. Context *Background/theory.* The empirical background of the pattern, evidence for its validity, variation of manifestation and expectations.
Relations/connections to other design patterns

A central idea of trialogical learning is that work and learning are *organized around developing some shared objects of activity*, such as conceptual artefacts, social practices, or products. In our case, we strived to establish practices concerning observing, reflecting and analysing the team's performance and introduced a model as a starting point for these activities, see Figure 9.5. The APCER model reminded participants about central issues and structured their discussions that were otherwise rather unstructured. As they needed to relate to the categories of the model, their discussions appeared more structured. The model ensured that participants addressed issues otherwise at risk of being overlooked.

The model provided clear goals to relate to during teamwork and a terminology for discussion. Introducing a new model always raises the risk of controlling and limiting the discussions too much. We have, however, not seen that this was the case: issues going beyond the model were still discussed. Sometimes the model itself was discussed; e.g., discussions about potential clashes between desired but conflicting goals. Another possible disadvantage of introducing a new model is that the model needs to be learned and understood by the course participants, which uses up valuable time that could be spent on other things. Therefore efforts have been put into creating a model that is as simple as possible.

Figure 9.5. The essentials of the course are summarized in a model of a complex domain.

The rationale for the APCER model is captured in the educational design pattern *Highlight the essentials* – presented as the first of three design patterns below.

Highlight the Essentials

Introduction: This pattern concerns problems related to learners who are overwhelmed in a new domain and in need of structure that makes explicit the most important concepts of a domain as a start for developing new knowledge practices.

1. Problem and forces

- Learners may be overwhelmed by the complexity of a new domain.
- Course participants may lack knowledge about and fail to see the importance of essential activities like making analyses
- Course participants do not expect to learn to make such analyses
- Participants may have wrong expectations about expertise; a common misconception is that experienced practitioners master teamwork and leadership skills, and that skills are implicitly picked up through experience.
- Other problems concern design or presentation of the essential concepts; if a model is too complex it risks not being learned, used and remembered.

2. Solution

Therefore, provide a simple model making explicit the most important concepts and tasks to support learners to start developing new knowledge practices. Base the model on other well-known models to support learning.

3. Context

Use when structure is important and when focus and precision in analyses are desired but when there is limited time to study more complex models, or if a goal is to develop a shared understanding or coherence in the team's views. Beware of risk of over-simplification if a model is taken as the final truth.

Background/theory

This design pattern draws on organizing trialogical activities around shared objects (DP1) and long-term processes (DP3). This pattern provides in part the shared object, or at least something learners can start from. A simple model is expected to be adopted, learned, remembered, and used over time: The focus that the design pattern provides supports collaborative knowledge construction regarding the analysis.

A common misconception among course participants is that experience per se is the key to mastering teamwork and leadership skills. This is not always the case (Cooper & Wakelam, 1999), and there is therefore a need to make explicit some norms and key behaviours. Using a model with key concepts of the domain structures and reduces the overwhelming complexity for novices.

Relations/connections to other design patterns

- Closely related to Analyse and score performance continuously (below)
- Cf. also Early Bird, Toy Box, and Lay of the Land (Bergin, 2000).

An ultimate objective of the course was not to only to change behavious in a short term during the course but to ensure patient safety in the future. Fostering long term processes and interaction between different forms of knowledge motivate the second design pattern – *Analyze and score performance continuously.*

Analyse and Score Performance Continuously

Introduction: This pattern concerns lack of awareness and a shared understanding among learners and suggests a solution involving continuous analysis practices.

1. Problems and forces

- Lack of awareness of own and other's performance during simulations
- Learners lack a common, shared understanding.
- Weak connection between theory & practice: need to conceptualize practices.
- During (resuscitation) work there is usually very limited or no time for learners to reflect on their behaviour
- Learners tend to overly agree with each.
- Learners tend to overly focus on own performance, often in critical ways.
- Theoretical concepts can be considered self-evident on an abstract level but learners may fail to see their relevance to actual practice.
- Conflicts between different goals risk going unnoticed.

2. Solution

Therefore, let participants take part in continuous analysing practices. Carry out these immediately following each simulation, not just at the end of the day or course. Iterate practice (simulation) and reflection (APCER-assessment/debriefing). Provide a set of key concepts. Use a simple game-like scoring (0, 1, 2) to minimize required time.

3. Context

- Use when practice is based on more than one case
- A drawback is the added time that is required by continuous analysis activities.

Background/theory

This patterns draws on the design principles of transformation between forms of knowledge and long-term practices (DP 3 and DP 4), and organizing trialogical activities around shared objects (DP1). The novelty of this practice is that the assessment is not only done by trained observers or instructors but the participants themselves, continuously, and explicitly supported by a model and scoring, and that the objective is educational and not assessment.

The objective is to change learners' practices during the courses and over time. The simplicity of the model helps learners remember so that they can go on doing the analyses on their own outside the courses. The individual scores immediately reveal similarities and differences between participants' observations: conflicting observations become apparent which may promote discussion. The game-like aspect of the scoring can be motivating.

An expectation is that the continuous analysing and scoring will lead to participants becoming more aware of problems in the teams' performance, which will contribute to the collaborative analysing.

Relations/connections to other design patterns

- Cf. also Spiral (Bergin, 2000)
- Closely related to Highlight the essentials

As the level of engagement and dominance among the participants may vary, some individuals may be heard more at the expense of others. A risk is that the analyses of some participants are not considered sufficiently, and that analyses are influenced by the contributions of a few participants. One of the design principles highlights supporting the interaction between personal and social levels and we have documented one order, which worked well in this context in the third design pattern below, *First individually, then as a group*.

First Individually, then as a Group

*Introduction***:** This pattern concerns phenomena such as individuals being influenced by their peers at the expense of individual views and uncritical agreement in groups. The pattern therefore suggests promoting knowledge practices which allow individual activities preceding collaborative ones.

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1. Problems and forces

– Immediate group discussions following on simulations will influence perceptions of the preceding activity and thereby hinder creation of personal analyses by each individual
– The team does not utilize its potential capacity of learning from each of its members. There may be uncritical agreement among team members. Members may not be aware of other members' views. Some students may be quiet while others dominate and not get the chance to speak their voice

2. Solution

Therefore, following each simulation, first create individual analyses and only later share, discuss and negotiate these collaboratively. Let each individual first create an individual assessment/evaluation following each practical exercise (simulation). These are shared in public and then the team attempts to reach a common view.

3. Context

– Works best in the beginning of courses when participants have not yet developed a common language.
– This pattern may be too complicated and time-consuming and therefore not appropriate in every context. Learners may also feel that they want to talk freely before engaging in personal assessments rather than reflect individually.

Background/theory

The pattern draws on the personal/social levels design principle (DP 2). With this solution, conditions for collaborative knowledge-creation are created; the team's potential is better utilized and each individual member can contribute to the analyses while counteracting uncritical agreement. The expectation is that by providing each participant the possibility to first make an individual analysis before a collective one is done there is a greater chance of making use of the entire team's competence in the collaborative development of the analysis.

A trialogical approach to knowledge creation should provide tools and practices for supporting knowledge practices and collaboration around shared objects, not just here-and-now but also for long-term processes. In this case, attempts were made to foster new practices; attending to, observing, and, analysing teamwork and communication. The course provides tools and practice enabling course participants to develop these practices also in other contexts. A challenge was that collaboration between the participants needs to take place under time pressure and the participants must therefore, have the necessary conceptual tools for analysing their performance in beforehand. Another challenge is that participants may lack knowledge about these skills and their importance. Therefore much emphasis is put on turning them into more explicit, salient knowledge practices. Through questionnaires participants reported that they improved at making analyses during the course. This is interesting since none of the participants mentioned that they expected to learn such skills in the courses.

The knowledge creation approach emphasizes development through interaction between various forms of knowledge and between practices and conceptualizations. The course constantly alternates between engaging practical simulation exercises and detached analysis during debriefings. The course participants take part in the deeply-involving simulations where various kinds of 'tacit knowledge' are displayed which is analysed immediately after using, among other tools, the APCER model. Before each simulation, the participants and the instructors collaboratively formulate ideals and goals, as targets to try to live up to in the exercises and to be analysed later. After simulations, the participants would assess and score the team performance using the APCER model. Initially, they occasionally had difficulties in interpreting the categories of the model. By iterating the process, they became familiar with the categories and were better able to connect them to concrete performance in the simulations.

A trialogical design principle can be useful in many different practices and cases (Paavola et al., 2011). Since they do not provide concrete solutions, design principles need active interpretation for use in a particular case and context. As illustrated in figure 9.6. design patterns can draw upon – or be inspired by – several design principles, which was also the case in this context.

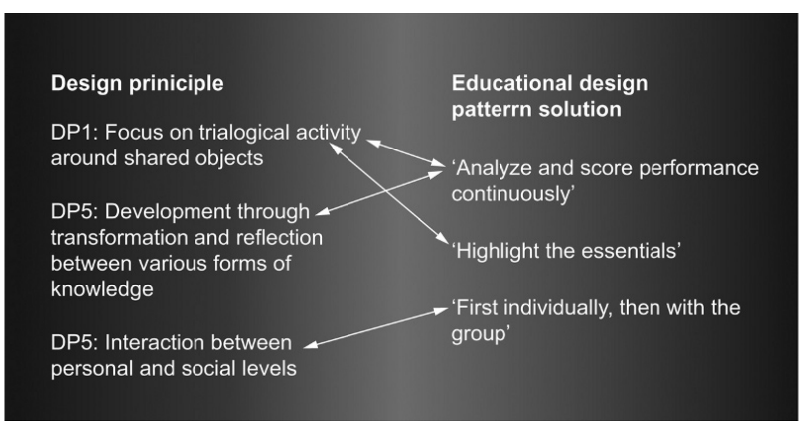

Figure 9.6. Educational design patterns are inspired by and relate to design principles.

Design patterns have the advantage of connecting concrete solutions to concrete problems and to indicate in which contexts they work. These solutions can be related to the abstract design principles. Design knowledge documented in design patterns adds flesh to the design principles and can be useful in other contexts and cases. The patterns can thereby inspire other cases and provide knowledge about how, when and why a solution could be useful in a way that principles are not able to. Moreover, one pattern can draw upon theoretical ideas from numerous sources. Consider, for example, design pattern *highlight the essentials*, with the APCER model; it could be viewed as being based on ideas about fostering long-term processes as well providing shared objects or transforming between different knowledge formats. It is a solution to several problems but hardly based on one design principle and hardly something that can or should be generalized as a prototype example following a specific design principle. For this case, the three design patterns were developed – inspired by one or more design principles.

The educational design patterns describe parts of the pedagogical model of the case explaining successful parts of the setting. The patterns thus suggest solutions to educational problems and challenges, and in which contexts these might work. The suggestions are small contributions to what a pedagogical model aiming at knowledge-creation can look like in a certain context. Their strength is that on a concrete level they illustrate how the third metaphor of learning was emphasized in the transformation of a case. However, it should be pointed out that neither design principles nor design patterns could specify or determine activities of knowledge practices in a strict way. There are many factors, which could prove the solutions in the pattern are wrong – for instance, a favourable attitude of the participants may be crucial for the design patterns to work. Nevertheless, the patterns contribute to describe the solutions that were successful in this particular case. The context descriptions are formulated on a quite general level. While the expectation is that the design patterns are more general than the specific case described here, investigation in other settings is needed to establish this claim.

CONCLUDING REMARKS

The knowledge creation metaphor and the trialogical design principles have inspired the design and development of educational practices of this case by highlighting certain aspects rather than others. 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 or handing over responsibility for the analysing to course instructors.

In the domain of neonatal resuscitation the importance of established routines is heavily emphasized and individual creativity is generally not prioritized. The case was initially far from a trialogical one and the simulation course was firmly placed in a rather traditional medical education context not really promoting collaborative knowledge creation activities among learners. Expectations in the learning context have, therefore, made it challenging to modify this into a more trialogical case.

However, the case as presented here illustrates how a trialogical approach can play an important role in modifying an educational context and, thereby, contributing to valuable improvement of the medical teams' practices.

It would of course have been conceivable to approach the case from other perspectives and to start out from other possible metaphors of learning. But, then, emphasis would probably not have been on the activities discussed here. One approach could be to let experts convey their insights about existing theories and assessment methods by giving more lectures or literature. Such an approach might be described as being in line with the knowledge acquisition metaphor. Another approach is to argue for the importance of getting more opportunities to practice; this could be provided by offering more simulation cases. Yet another approach would be to emphasize more exposure to experienced practitioners' activities or by more mentorship programmes. Such approaches often relate to apprenticeship models that are theoretically founded in the participation metaphor. The apprenticeship model has a strong tradition in medicine; less experienced doctors learn from observing and working together with more experienced specialists. However, Yaeger and colleagues discuss an assumption underlying medical education and training which has recently been called into question (Yaeger et al., 2004). This assumption is that '[a]ll clinical role models are effective and skilled, and all behaviors demonstrated by these roles are worthy of replication' (p. 326). While these other approaches have obvious advantages, they are not necessarily the most appropriate and do not handle the problems addressed by the course.

As experience alone does not guarantee good teamwork and efficient communication, a trialogical approach to knowledge creation turned out being a fruitful approach to highlight the development of knowledge practices which needed to be improved, and giving valuable hints about directions the design and development of educational practices should proceed. The knowledge creation metaphor and the trialogical design principles contributed important support to improvement of the medical teams in ways that other approaches probably would not have. The case has involved development of collaborative knowledge creation practices that address many of the initial, acknowledged problems when the case started. The word 'inspired' has been used about the design principles throughout the chapter to reflect that the chosen design principles do not specify or determine a design in a new context, but provide ideas and direction when there is interest in encouraging knowledge creation practices. Especially prominent or successful features of the case are described as educational design patterns, making them useful in other contexts and contributing to the theory about the trialogical approach to knowledge creation. The design patterns describe a problem, how it is solved in the case, and links the solution to those design principles the solution draws upon. The design patterns feed back to the theory by enriching the high-level design principles connecting them to real problems and, thereby, concretizing their meaning. The analysis of the detailed interactions resulted in findings that contribute to our understanding of knowledge creation activities in cases of this kind. The analysis also led to development of a model to describe typical trajectories of interactions in the case.

The emphasis on novel knowledge practices among the course participants modifies the view of the 'tacit knowledge' addressed and explicated in the course. The tacit knowledge addressed is no longer assumed to be some kind of hidden skill possessed by experienced practitioners, and no longer expected to be extractable from the video recordings of the medical simulations that are analysed during the debriefings. As pointed out, experience is not a guarantee of effective leadership in teams and it may be misleading to assume such tacit expertise, even among experienced practitioners. The 'tacit knowledge' which is addressed in this case is, rather, something very unmystical and prosaic: a knowledge practice which the course attempts to promote and foster among its course participants, namely continuous, critical, constructive and collaborative analysing of the medical teams.

NOTE

[1] Only those with a great deal more experience were likely to be more effective (more than 50 resuscitation attempts over a 3-year period).

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10. A PRODUCT DEVELOPMENT COURSE AS A PEDAGOGICAL SETTING FOR MULTIDISCIPLINARY PROFESSIONAL LEARNING

INTRODUCTION

New product development (NPD) is a relatively recent discipline that concerns the management of new product introductions (Lantos, Brady & McCaskey, 2009). Over recent years, it has motivated pedagogical innovation in the training of new product development professionals (Ettlie, 2002; Lovejoy & Srinivasan, 2002; Pun, Yam & Sun, 2003; Shekar, 2007; Silvester, Durgee, McDermott & Veryzer, 2002). However, according to Lantos, Brady and McCaskey (2009), only nine percent of the 407 institutions with undergraduate business training programs in USA included in their study offered NPD courses.

New product development is a process in which the aim is to transform creative ideas into marketable products. This process includes working activities like identification of marketing needs, product idea generation, industrial design, product cost analysis and market launch planning. Teaching the NPD process is a challenging task that requires supervision, guidance and instruction (Elshorbagy & Schonwetter, 2002). During the course, trainees should be involved in industry-relevant projects in order to become capable professionals in the field (Cardozo et al., 2002). In addition, people developing new products in teams have different professional orientations, perspectives, and skills, which complicates interaction but also facilitates creativity and vision. Therefore, multi-disciplinary course settings rather than academic courses in one discipline alone can optimally prepare an individual for these challenging cross-functional environments (Lantos, Brady & McCaskey, 2009). Beside the importance of interdisciplinary educational settings, cross-fertilization of knowledge practices between real working life and educational institutions has been raised as a mechanism that should be capitalized on in training innovative professional designers (Lakkala et al., this volume). Miller and Watts (Miller, Taylor & Watts, 1983; Watts, Guichard, Plant & Roderiguez, 1994; Watts, Hawthorn, Hoffbrand, Jackson & Spurling, 1997) defined cross-fertilization as a specific form of collaboration, which occurs when collaborators make efforts to share and exchange skills as well as work across professional boundaries in ways that may readdress or redraw the boundaries themselves. This definition of cross-fertilization can be regarded as parallel to the

A. Moen, A. I. Mørch, S. Paavola (Eds.), Collaborative Knowledge Creation: Practices, Tools, Concepts, 185–202.

notion of *new horizontal links* between diverse activity systems, considered as a crucial learning opportunity (Engeström, 2001; Kerosuo & Engeström, 2003).

In the present study, the *trialogical learning* approach provided a general framework for investigating key aspects of a course teaching new product development. This approach emphasizes ways of organizing the activities of learners as systematic work around shared artefacts (and objects) created for some subsequent use and purpose (Paavola & Hakkarainen, 2009; cf. Ewenstein & Whyte, 2009). In trialogical learning, individually performed activities, social interaction and collaboration serve the longer-term processes of using and developing knowledge artefacts and related practices, which is often not the case in conventional educational practices. *The cross-fertilization of practices between educational institutions and professional communities* is considered to be a powerful mechanism promoting trialogical learning (Paavola, Engeström & Hakkarainen, this volume). The "strong" forms of cross-fertilization are sought where the representatives of different institutions engage in collaboration for developing shared conceptual or material artefacts for some subsequent use.

The trialogical approach highlights the role of joint work on a wide variety of external artefacts. With regard to new product development, this includes various working documents, graphical representations and prototypes. The trialogical learning framework aims at shedding light on how joint work on these artefacts harnesses and transforms the initial ideas and evolving knowledge of collaborators, and converts them into viable solutions.

Two Dimensions of Collaborative Knowledge Practices: Conceptual and Relational

The present study explored *professional-like knowledge practices* that the students were engaged in during a multidisciplinary course in which they developed business ideas and technological solutions for real customers. Two dimensions of activities in particular that are central in a trialogical working process were put at the forefront in the study. The *first dimension* that is epistemic by nature is called *conceptual agency* (Greeno, 2006a; 2006b; 2007; Greeno & van de Sande, 2007; Engle, 2007; Pickering, 1994). This is involved when an individual or group interacts with some subject-matter constructively by interpreting related meanings and problems, modifying concepts, evaluating, adapting and choosing approaches to problems as well as designing material artefacts. According to Greeno (2006a), the educational settings that promote conceptual agency position students with *authority, accountability and access* to various resources to be used, adapted and combined in unconventional ways. Engle and Conant (2002) pointed out that this kind of setting should hold students accountable both to *relevant disciplinary norms* and to the *content and practices established by intellectual stakeholders within and beyond their immediate learning environment*.

The second dimension of agency investigated in this study, *relational agency*, partially overlaps with the collaborative aspect of accountability specified by Engle and Conant. Edwards (2005; Edwards & D'Arcy, 2004) defines relational agency as *a capacity to align one's thoughts and actions with those of others to expand the* *object that one is working on*. Relational agency comes to the fore when actors set out to expanding the object of their activity by recognizing the motives and the resources that others bring into the interpretation of the object (Edwards, 2010).

In the present study, the way conceptual and relational agency *serving product development* was particularly concerned in the instructor's guidance and then reflected in the students' activities was analysed. Some of the analysed data constituted the interactional steering group sessions in which the instructors had to adjust their guidance to the context specific needs and problems of the students in the current state of their (product development) project. Since the instructors' guidance during these sessions did not follow any pre-set didactic or interventional procedure, it was legitimate to consider both the content of the guidance and the related actions of the students. The notions of conceptual and relational agency served as basic categories in analysing the data.

RESEARCH QUESTIONS

The pedagogical presupposition for the teachers of the course under investigation was that in order to succeed in the collaborative development of project artefacts and technical solutions the students needed guidance from the teachers and professionals representing multiple domains of expertise and providing insights into the commercial and customer-dependent work processes. The study aimed at shedding light on how the course set-up emphasizing cross-fertilization functioned as a pedagogical mechanism in training new product development professionals.
Consequently, two research questions were formulated:

1) *How were the issues related to conceptual agency reflected in the instructors' guidance and the related revisions made by the students in the artifacts analysed?*
2) *How were the issues requiring relational agency reflected in the instructors' guidance and the related revisions made by the students in the artifacts analysed?*

The investigation was directed to the initial phase of the course when the students had begun to extend their explorations of the problem space after the basic ideas behind their projects were brainstormed. During this period, the students were supposed to make use of analytical conceptualizations and methods embedded in the working documents (templates provided by the teachers) and implement these working documents as conceptual resources to clarify and improve their business ideas and related technical solutions. The use of the working documents was also stressed in the guidance that the students received in the steering groups.

METHOD

Setting

The setting investigated in the study was a course organised at the Metropolia University of Applied Sciences in Espoo, Finland, lasting from September 2009 till March 2010. The course purported to promote the learning of various professional practices featuring the development of business ideas and related services as well as multimedia products in real working life. The investigation was one of the case studies conducted as a part of KP-Lab project (Knowledge Practices Laboratory).

A total of 50 students from three degree programs at Metropolia University of Applied Sciences participated in the study: media engineering (n = 18), industrial management (n = 30) and communications (n = 2). Four teachers from these degree programs (2, 1, and 1 respectively) participated. Four customer organizations were closely involved in the process: a small company specialised on online recommendation services (5 representatives), a large mobile phone company (2), a small music company (1) and a small photo company (1).

The students worked in 11 multidisciplinary teams, 3–6 members, to develop business plans, user stories, a marketing strategy, and software architecture to come up with an application. The students were introduced to practices and methods used in business and application development through several expert lectures. Some lectures were given by visiting experts from business settings.

Working documents (templates) *pre*-structured with domain-specific conceptualizations were used to guide the students' work on their solutions and analysis of related problem spaces, e.g., market size, potential users and their problems. In addition, the teams were instructed to develop such documents as user stories, software architecture, mock-ups, prototypes, sales pitches, and weekly team progress reports. These documents, along with other team products, were presented and discussed during weekly steering group sessions.

The "steering groups" consisted of 1–2 teachers and 1–2 customer representatives. In the autumn they were held weekly, lasting from 15 to 45 minutes. The goal of the steering groups was to support the teams in addressing all relevant aspects of business planning, software development, and acquiring users (and business revenue) for their application.

A virtual working environment, called the Knowledge Practice Environment (KPE), served as a shared working space during the course. The KPE was developed in the KP-Lab project as a flexible digital working space, especially supporting collaborative knowledge creation practices and trialogical learning (Bauters et al., this volume and Lakkala et al., 2009). This environment consisted of a common working space for all course participants and separate working spaces for each team, which were accessible to all. The instructional materials, working documents and timetables were uploaded into the common working space.

Figure 10.1. Student teams' Project plan and Business plan uploaded to KPE.

The students were introduced to the basic functions of KPE at a demo session at the beginning of the course. The student teams were supposed to make use of the functions to structure their work into sub-tasks, define their timeframe and organize diverse working documents and joint elaboration on them in their own working spaces (Figure 10.1). Cross-fertilization of practices was realized in three core elements of the course setting. *First*, students came from diverse training programs; media engineering, industrial management, and communication. *Second*, students were provided with various analytical, reflective and managerial documents based on existing professional practices for promoting object-bound knowledge creation. *Third*, the steering groups guiding the student teams were composed of teachers and customer representatives representing working life.

Table 10.1. Overview of the students' activities

<table>
<tr><th>Month</th><th>Sep 09</th><th>Oct 09</th><th>Nov 09</th><th>Dec 09</th><th>Jan 10</th><th>Feb 10</th><th>Mar 10</th></tr>
<tr><td rowspan="5">Students' activities</td><td colspan="2" rowspan="3">Draft generic ideas for business solutions, elaborate business plan, specify application, create first prototypes</td><td colspan="2">Continue work on the business plan, improve application prototypes</td><td colspan="3">Realizing the business plan with real customers by implementing developed service and product</td></tr>
<tr><td colspan="3">Creating a marketing plan
Creating a financial plan</td><td colspan="2"></td></tr>
<tr><td colspan="5">Creating and revising the project plan</td></tr>
<tr><td colspan="7">Designing the product, coding, testing</td></tr>
<tr><td colspan="7">Collaborating with potential customers</td></tr>
</table>

Table 10.1 provides an overview of the timeframe of the student activities taking place during the course.

Participants and their Product Development Project

One of the student teams was randomly selected for an intensive follow-up at the beginning of the course. The team had two industrial management students and one media engineering student, and was developing a mobile application meant to be used in monitoring gym exercises and personal development of trainees related to these exercises. The client partner of the team was a large mobile phone company.

When the first analysed steering group sessions took place, the team had already come up with the initial ideas of the business and application development projects that it pursued further. During the research period, the team was realising and elaborating on these ideas by working on business plan templates and creating user stories for creation of the applications. In addition, it was already working on the prototype of the application being developed and had created the first draft of brief presentations on the product envisioned for potential customers. Two representatives of the mobile phone company and two teachers were present at the steering group meetings. In addition, two other student teams and representatives of companies assisting their project work participated in the same meetings.

Data Collection

The data collected included four video-recorded steering group meetings of the team, progress reports created after each session, and changes tracked by comparing four subsequent versions of the team's business plan. The template of the progress report included such sections as Status, Risks, Contingency plan, and Next Steps as well as the following questions:

> *What has taken place with your team's project during the past week? E.g., how have you progressed, and what has been difficult?*

> *What have you found helpful during this past week (materials, tools, expert guidance, team activities, etc.)?*

> *What are the main issues that you have in mind at the moment for continuing the project? These might include problems and challenges the team needs to deal with.*

The versions of the team business plan of the team business plan for comparison were created after each steering group session reviewing the team's progress. This provided an opportunity to explore how the received comments were taken into account by the team in the subsequent changes.

The pre-structured template used in the business plans (see Figure 10.2) included such sections as Vision, Value, Industry, Customers, Customer problem, Business Model, Offering, SWOT-analysis (from the words strengths, weaknesses, opportunities, threats), and Market research (Market size and competitors). One of the teachers had created the template by combining various analytical and working conceptualizations and methods widely used in business and product development. The template was meant to provide guidelines for the team activities when they worked on their projects.

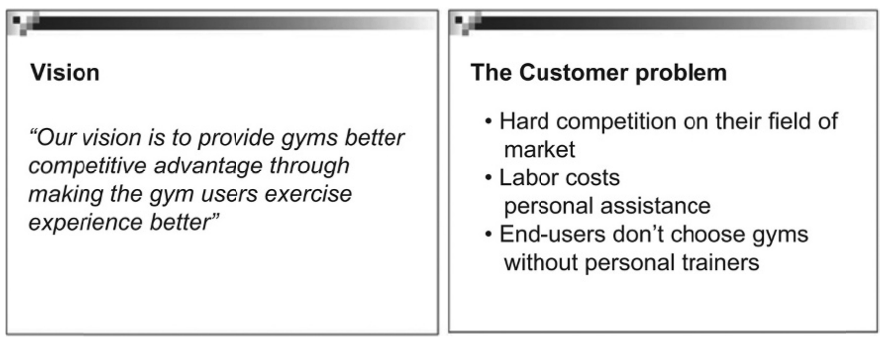

Figure 10.2. A version of the business plan of the team, presented as Power Point slides.

Data Analysis

In the data analysis, the aim was to capture the process in the course,,where the revised working documents of the students were reviewed by the teachers and company representatives, which, subsequently, changed the direction of the process and produced further revisions of the documents. The data sample consisted of four video-recorded steering group sessions during which the team's work was reviewed along with the changes in its business plan after the sessions.

Data analysis consisted of three phases: a) Analysis of the content of all oral comments provided by the teachers and client representatives for the team; b) Analysis of changes made by the team in their *progress reports* after each steering group meeting; and c) Detailed analysis of the consequent revisions of the *business plan.* Each analysis phase is described below in more detail.

Table 10.2. Main categories related to conceptual agency

Category	*Description*	*Sample quotations*
1. Development of technical application	Comments or questions concerning the character of the application or tools, or means being used in its development and creation.	"The question is whether the same training program can be used by many people, or if it is always unique, because that will affect your design?" "I think it's good to make a user story for both trainer and trainee to cover the whole program."
2. Creation of a business plan	Comments or questions about various aspects, circumstances and constraints related to the business idea being developed and/or their presentation in the business plan.	"You should be more precise in defining industry and think how to construct a vision in one sentence"

Table 10.3. Main categories related to relational agency

3. Coordination within the students team	Comments or questions about division or order of tasks, responsibilities and roles, information flow in the teams.	"Have you done any kind of project plan?"
4. Contacting and collaborating with potential customers	Comments or questions about the team members' attempts to initiate contacts with potential customers and collaborate with them.	"It could also help if you go and meet customers. You can try to figure out how many users they have if this kind fabrication existed, what they think, how many people would use it." "It would be good to meet a personal trainer for half an hour and find out problems they have."
5. Presenting business ideas or solutions to others	Comments or questions concerning the presentations created with to describe the basic characteristics of the business ideas and applications	"Whenever you do a presentation you need to think about your audience, think what they are interested in and what they know about the topic, what they don't know, in what order it would be good to present the stuff that they will get on board to nice ideas."

On the basis of the preliminary analysis the comments of the teachers and client representatives during steering group sessions, five main analytic categories for the qualitative analysis of their content were created. Two of these categories reflected acting with conceptual agency (see Table 10.2), whereas three were related to the activities requiring relational agency (Table 10.3).

The comments of the teachers and company representatives at the steering group meetings were categorized into the aforementioned categories with ATLAS.TI software after watching each video recording 2–4 times. In the second phase of the data-analysis, *the changes* between subsequent *progress reports* of the team made after the steering group meetings were tracked and scored into the same analytical categories as the comments made at the meetings. In the third and last phase the data-analysis focused on the subsequent revisions to the business plan made by the students. These revisions were categorized in more detail to determine how the actions requiring conceptual and relational agency were reflected in the changes in separate sections of the business plan- document. The 1st and 2nd main categories *related to conceptual agency,* and the 5th main category, *related to relational agency,* were used and specified with sub-categories for this purpose.

For Category 2: *Creation of a business plan* (see Table 10.2), five sub-categories were created, relating to the comments on various dimensions of business ideas and their implementation. This group reflected the overall structure of the business plan template, including the following sub-categories 2a) *Vision*, 2b) *Description of industry*, 2c) *Definition of customer or customer problem*, 2d) *Market research*, and 2e) *Definition of business model*. In addition, two data-driven analytical sub-categories were created. Under Category 1: *Development of technical application*, a sub-category 1a) *User stories* was created, and under Category 5: *Presenting business ideas or solutions to others*, a sub-category 5a) *Use of visual representations* was created. (see Tables 10.2 and 10.3). The rationale for this was that *both* the work on the user stories mediating the development of the application and the use of graphical illustrations in presenting business ideas and solutions to others were frequently involved in the guidance. *All seven sub-categories* were subsequently used to analyse the changes in the succeeding versions of the team's business plan.

RESULTS

The Focus of Topics Guiding Discussions and Related Changes in the Team's Progress Reports

The *Table 10.4* shows the summary of results concerning the guidance from the teachers and company representatives, and its influence on the team's working process according to progress report using the main categories of the analysis.

The numbers in columns SG I- SG IV of table 10.4 indicate the frequency of the comments scored in each analytical category. Columns PR I- PR IV show the number of changes in the subsequent versions of the progress reports scored in the analytical categories.

Table 10.4. Comments during the steering group meetings and changes made in the team's progress report

	Comments at the steering group sessions (SG)/ Changes in the progress reports (PR)							
	SG I	PR I	SG II	PR II	SG III	PR III	SG IV	PR IV
Categories related to conceptual agency								
1. Development of the technical application	11	1	10	2	5	3	10	3
2. Creation of the business plan	19	2	0	2	2	0	7	1
Categories related to relational agency								
3. Coordination in the students team	1	0	3	0	1	0	0	0
4. Contact and collaborate with potential customers	6	1	0	0	5	2	15	3
5. Presenting business ideas or solutions to others	1	1	5	2	0	0	7	0

As the table demonstrates, the development of technological application was frequently dealt with during the steering group meetings. The creation of the business plan was addressed in numerous comments during the first meeting, whereas the issues related to contacting and collaborating with potential customers predominated in discussion at the last two followed meetings.

Closer analysis conducted on the changes in the business plan revealed that the comments given to the team at the steering group meetings were followed by multiple revisions in its business plan (Table 10.5). The columns of Table 10.5 shows the number of revisions tracked in the versions of the business plan created after each steering group meeting. The rows of the table summarize the number of revisions in each analytical category.

Table 10.5. Revisions of the Business plan

Topic or character of comments and changes	*Changes after SG I*	*Changes after SG II*	*Changes after SG III*	*Changes after SG IV*
1. Development of product (conceptual agency)	5	0	0	4
a) User stories	2	0	0	0
2. Creation of business plan	9	1	4	1
a) Vision	1	0	0	0
b) Description of industry	1	0	0	0
c) Definition of customer or customer problem	1	0	1	0
d) Market research	3	1	2	1
e) Definition of business model	3	0	1	1
3. Presenting business ideas or product (Relational agency)	4	1	9	0
a) Use visual representations	0	1	9	0

As the able demonstrates, the work on the content of the business plan was particularly pronounced in the revisions made after the first steering group meeting. The revisions of the sections of the business plan document meant for presenting the product to others were frequent in the version created after the third steering group meeting.

In what follows, more detailed findings related to the guidance given and the student team's subsequent actions are presented separately for the relational and conceptual dimensions of agency. The results below are based both on the findings from the analysis of the progress reports (Table 10.4) and the analysis of the business plans (see Table 10.5).

Findings on the Guidance and Students' Actions Related to Conceptual Agency

The data in the 1st and 2nd main categories (Tables 10.4 and 10.5) shows how conceptual agency was involved in the guidance and reflected in the actions of the students.

Development of the Technical Application

The team worked on a creating a functioning prototype of their product during the period monitored in the study. The analysis of the comments from the steering group sessions revealed that at the very beginning of the period, the team received numerous comments regarding the development of the technical application. As the following examples demonstrate, many of these comments took the form of questions on the design that the team was working on:

> Example 1: (One of the teachers at SG I): “How do you resolve problems with the use of Bluetooth?”

> Example 2: (The representative of the mobile phone company at SG I) “Is there some kind of sensor, Bluetooth equipment counting the time you are exercising?”

> Example 3: (The same representative at SG I):“I think it’s good to make a user story for both trainer and trainee to cover the whole program.”

After the first steering group meeting the team created user stories meant to support the work on the application. The changes made in progress reports and the version of the business plan created after SG IV indicate that the team reconsidered the choices regarding the technology they used. The work on the development of the application was reflected particularly in the revisions made in the fourth and last version of the business plan. Unlike the previous versions, the team presented the GPRS as the basic mobile phone technology that the application was based on in this version instead of the original idea of using Bluetooth technology.

Creation of the Business Plan

During the first steering group meeting, the team received feedback challenging them to clarify and firm up the sections of their business plan. The following example illustrates the character of these comments:

> Example 4 (The representative of the mobile phone company in SG I) “It would be good on the first page to state the size of the business, how many gyms you find in certain area, how many people will use them…Right now you have assumptions with no analysis”

In the progress report following the first steering group session, the team stated that its members had read research about gym users in Finland and had found the website of one leisure sport organization a particularly helpful resource in this respect. After the first session, the revisions made in the team’s business plan (Table 10.5) focused on the sections specifying the business idea of the team’s project and the related problem space (the peculiarities of the targeted market). The team presented its findings concerning the market environment related to its project in more detail as a result of their familiarization with the research on gym users after the first steering group meeting. The team defined its vision more concisely, expanded the description of its business model by clarifying related pricing principles and specified its offering in the second version of its business plan. In the last two versions of the business plan, the team presented some supplementary findings from the market research.

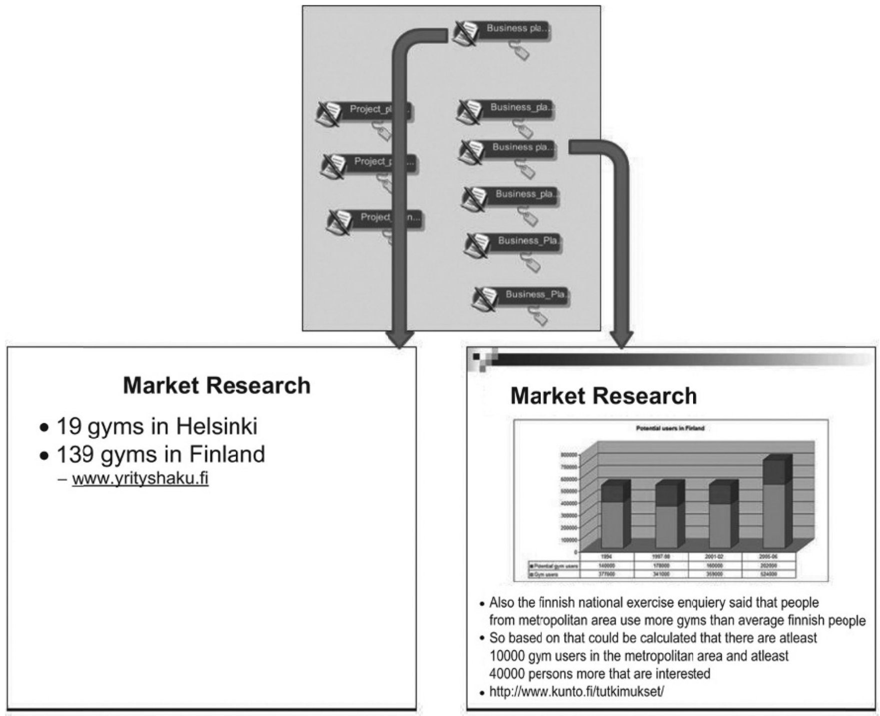

Figure 10.3. Business plan of the team, the first slide (below, left) is the first version of the plan, the second slide (below, right) is the third version of the plan uploaded in KPE.

Findings on the Guidance and Students' Actions Related to Relational Agency

The data scored in the 3rd, 4th and 5th main categories provided findings on how the actions requiring relational agency were addressed in the guidance and how relational agency came to the fore in the students' activities.

Coordination within the student team

The issues related to the coordination within the student teams were discussed at the steering group session less frequently than those related to the other categories, and were addressed in routine like questions or brief comments (Table 10.4). Coordination within the student team was not mentioned in the subsequent versions of its progress report either.

The small number of comments related to coordination issues might be due to the simple structure of the team (two industrial management students and one media engineering student) allowing its members to orchestrate their joint actions easily.

Contacting and collaborating with potential customers

During the first sessions, the students had already been encouraged to initiate contacts with potential customers and implement these contacts as knowledge resources in working on their business ideas and plans:

> Example 5: (One of the teachers at SG I): "It would be good to meet a personal trainer for a half an hour and find what problems they have."

As the next example illustrates, the comments related to contact with potential customers and partners might also provide some ideas about how to make use of these contacts in marketing the solutions being developed:

> Example 6: (One of the teachers at SG III): "Could one possible costumer be for instance a company that sells these...what are they called... athletics soft drinks. You know, they could brand this kind of application and use it as an advertisement... Try to visit this kind of company."

After the first steering group meeting, the team stated in its progress report that it was planning to visit gyms to get information about customer interest in the application that it was developing. However, the team also described the lack of interest on the part of gyms as a risk in its subsequent report, despite not having visited any. As the following excerpt from the fourth steering group meeting demonstrates, the students' concern over the lack of interest from the gyms was challenged by one teacher as a preconceived notion:

> Example 7 (One of the teachers during SG IV): "So you actually don't know whether gyms are interested or not, you just suspect that they are not."

At the same fourth meeting, the company representative shared his thoughts with the team members about how the busy staff in gyms could be approached and familiarized with the application. He thus tried to encourage the students to think about efficient ways of grabbing the attention of gym users in these environments, as can be seen in the following comment:

> Example 8 (The representative of the mobile phone company at SG IV): "Your challenge is to get this person out of that environment and have them say well can we go talk about it, get a kind of first nod or approval and get to his office."

In its last report, the team stated that it was planning to email a small query to some personal trainers.

Presenting business ideas or solutions to others

During the research period, the team created a brief presentation for gyms about the technical application that it was designing. The draft of this presentation evoked multiple comments at the steering group sessions. As the following examples demonstrate, these comments aimed to draw the students' attention to the state of knowledge and background of their target audience:

> Example 9 (One of the teachers during SG II): "It would be ideal if in every presentation and especially at a costumer presentation that you think about these headings... It would be better to put this (pointing to the slide) as a heading because this is a key message."
>
> Example 10 (One of the teachers during SG II):" It would be great if there was a picture of a mobile phone and a server."

The second version of the team's business plan contained a revised customer presentation. The revisions were mainly related to re-structuring the content and the implementation of visualizations. In the third version of the business plan, the team made further major revisions to its customer presentation by including new pictures about the existing application.

DISCUSSION

The analysis of the sequence of the supervision process included in the course revealed that application development posed diverse challenges to the student team, with both *epistemic (i.e., conceptual) (*Greeno, 2006a; 2006b; 2007; Greeno & van de Sande, 2007; Engle, 2007; Pickering, 1994) and *relational* (Edwards, 2005; Edwards & D'Arcy, 2004) dimensions. The *epistemic dimensions* of these challenges found their expression in the student interaction with complex subject matter that required them to act with conceptual agency. This subject matter involved the business idea being envisioned and elaborated, a related task environment (business environment, potential customers) and finally the technical application being designed. The need to address these professional challenges in higher education has been emphasised by the researchers and pedagogical designers in assuming the value of specific NPD courses (Ettlie, 2002; Lovejoy & Srinivasan, 2002; Pun, Yam & Sun, 2003; Shekar, 2007; Silvester, Durgee, McDermott & Veryzer, 2002). The work on subsequent versions of the business plan prompted the team to expand its efforts in analysing the task environment (for instance, the size of the business) related to the development of the application. The team was guided to specify its business idea by describing and analysing the related task environment using various professional conceptualizations (for instance, *vision* and *offering*). The students thus were held accountable to domain-specific methods in framing their initial ideas and analysing the related problems. At the same time, the students were provided with an opportunity to modify these conceptual resources and apply them in the specific context of their project. Finally, the team also selectively applied available mobile technology in designing the application. The development of the application led the team to shift from the technology used at the beginning (Bluetooth) to another more efficient alternative (GPRS). The aforementioned findings can be regarded as indications of the team members' *conceptual agency.* Conceptual agency came to the fore when the members were positioned with accountability, authority and access to various conceptual and technical resources as well as being provided with regular guidance in developing the application.

The students encountered *relational* challenges when they tried to initiate contacts and alliances with potential customers and partners and created presentations intended to make their ideas and solutions understandable to others. The course instructors, both the teachers and the client company representatives, emphasised the importance of collaboration and communication with potential customers in exploring the user problem addressed in the development of the application. The students were thus encouraged to act with *relational agency* by aligning their thoughts and actions with those of the potential users of the applications during the design process.

The findings of the study demonstrate that the instructional practices used in training new product developers need to guide trainees to act with both *conceptual* and *relational* agency. These two partially overlapping dimensions of agency required in development of marketable products are applied daily in related professional practices and are thus arguably embedded in the tacit knowledge of experienced professionals. Our findings shed light on how the working document templates highlighted the *object-driven* (i.e., trialogical) *character* of learning by structuring the student work on product development. This extends findings from previous research, which identified the importance of templates as a form of guidance in university education simulating distributed virtual project work (Muukkonen et al., 2010). *Firstly*, based on the conceptualizations used in professional practices, the templates mediated the participants' work on their projects, development of business ideas and products, and the analysis of related problems. *Secondly*, the participants' trialogical efforts found expression in the iteratively updated versions of these documents. The evolving working documents provided the teachers and company representatives with a window onto the development of the team's work on various domain specific issues (for instance, the analysis of business opportunities, the challenges in contacting customers). Consequently, the supervisors could focus their guidance on the issues with which the team was struggling most at a particular moment and help students to overcome their difficulties. Depending on the character of the team's actual problems, the teachers and company representatives were able to "tailor" their comments to address issues that most required painstaking conceptual agency or to emphasise challenges calling on the team members to act more with relational agency.

Since the trialogical approach places particular value on the use of artefacts iteratively developed and modified jointly, we suggest that the work on domain specific documents as a learning activity supervised by teachers and experienced professionals deserves attention in the new product development training in higher education.

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CRINA DAMŞA AND JERRY ANDRIESSEN

11. SHARED EPISTEMIC AGENCY FOR KNOWLEDGE CREATION: AN EXPLORATIVE CASE STUDY

INTRODUCTION

Knowledge creation entails collaborative learning processes, involving groups of students who deliberately shape their learning activities and act collaboratively in order to create and advance knowledge. In this chapter, we discuss shared epistemic agency as one of the main constructs capturing aspects of the process of collaboratively creating knowledge.

Collaborative learning practice in professional contexts is increasingly being related to creating new knowledge and efficiently applying this knowledge in current work. Although these challenges especially address the work place, current education is expected to prepare students for their future work in this knowledge society. In order to address these emerging challenges the educational system needs to make an epistemological shift. Paavola & Hakkarainen (2005) attempt to characterize a new epistemology of learning by proposing the *knowledge creation* metaphor. This metaphor builds on Sfard's aquisition and participation metaphors (1998) depicts a 'trialogical' view, in which learning is described as collaborative activities taking place during the creation of shared knowledge objects. This view on learning draws on the ideas of knowledge advancement through communities' contribution (Scardamalia & Bereiter, 2003) and activity theory ideas which maintain that all human activity is object-oriented (Engeström, 1987) and that activity revolves around shared objects. This latter feature involves that learners strive at collaboratively creating knowledge objects. It denotes the interaction between the participants and their shared object of activity and, consequently, the pursuit of advancing shared knowledge (Paavola & Hakkarainen, 2005).

When the educational settings are designed based on ideas derived from this theoretical framework, students are confronted with a big shift in their learning practices. In order to be able to actively participate in knowledge production, students are expected to take control of the strategic activities involved in learning (Scardamalia, 2002). Furthermore, they must go beyond individual efforts and collaborate with their peers for the advancement of their shared knowledge (Bereiter, 2002). We believe that these activities involve a gradual process characterized by qualitative changes in *agency*, or the capacity of students to deliberately act in collaboration, with the purpose of advancing their own knowledge. Although such ways of working are known from studies in professional practice (Nonaka & Takeuchi, 1999), not much is known about it in

A. Moen, A. I. Mørch, S. Paavola (Eds.), Collaborative Knowledge Creation: Practices, Tools, Concepts, 203–218.

the context of educational practices. We study students' ways of dealing with their collaborative learning during knowledge creation by proposing the concept of *shared epistemic agency*.

Hence, this study has an explorative character and aims at gaining a better understanding of the concept of shared epistemic agency in the context of collaborative knowledge creations practices at higher education level. Therefore we intend to describe the concept of shared epistemic agency elaborating upon theoretical perspectives, and we use empirical data to provide an insight into how we investigate this construct in empirical settings. This investigation is set up according to the following research questions:

What aspects of shared epistemic agency can be identified based on existing theoretical perspectives?

What type of activities characterize shared epistemic agency in the context of collaborative research activities of students in higher education?

These questions form the basis for discussing the concept of shared epistemic agency and the type of activities that take place when students are involved in creating shared knowledge objects. We begin by examining existing theoretical and empirical studies on epistemic agency, specifically within educational contexts. Next, a preliminary framework of the concept of shared epistemic agency is proposed. This is then followed by a summary of findings and an analysis of a case from higher education in an attempt to identify characteristics of shared epistemic agency in the empirical data. Finally, we reconsider and discuss potential directions in conceptualizing and capturing shared epistemic agency, with an eye on further research.

THE CONCEPT OF EPISTEMIC AGENCY

Etymologically, the term epistemic refers to knowledge, therefore, epistemic agency is considered the type of human agency that entails the learning of knowledge. This involves that agents are responsible for what they know and what they do not know, or, in other words, that knowledge arises from choices the agent is responsible for (Reed, 2001, p. 522). Epistemic agency is considered a form of agency, which, from a philosophical perspective, involves human beings having control of their course of actions and able to determine how to apply their will in concrete acts (Reed, 2001). Sociological approaches emphasize creativity as an element of agency (Emirbayer & Mische, 1998). Human beings possess the potential to distance themselves from the existing, known patterns of activity and to find new ways to express their ideas; agency involves examining alternative trajectories for future acts. Social-cognitive theory (Bandura, 2001) emphasizes the intentionality element of human agency, which implies purposefulness, acting based on clear intentions, determining the course of actions, and regulation of the activity by reflective means.

We consider agency as epistemic when it is applied for the main purpose of aquiring and creating (new) knowledge. Scardamalia and Bereiter (1991) described epistemic agency within the context of education as a principle in the design of the knowledge building communities. They described it as processes by which ideas are created and improved, in the context of knowledge building activities (Scardamalia & Bereiter, 2003). According to Scardamalia (2002), participants who take part in collaborative learning projects improve or develop ideas by means of collective contributions. In her study she points at epistemic agency as being a metacognitive ability related to goal setting, motivation, evaluation and long-range planning. Participants in this type of project relate their personal ideas with one another, monitor advancement of collective activities, and overcome challenges emerging in the process, activities which she relates to epistemic agency.

Using this approach to epistemic agency as a starting point, various approaches provided different interpretations for the concept, but few concrete operationalizational models. In a study on learning through knowledge building activities of medical professionals, Russel (2002) concluded that epistemic agency was realized through purposeful and progressive discourse between group members. In a study on teacher learning, Erstad (in progress) indicates that learners that were epistemic agents coordinated their personal ideas with others' by explicitly monitoring how their collaborative efforts were proceeding. Hakkarainen and Palonen's (2003) study on the nature of CSILE students' social network indicated a number of elements of epistemic agency. In their study, students considered to be epistemic agents showed evidence of taking a cognitively central knowledge building role in the classroom by initiating boundary crossing between groups of students: by brokering knowledge; by involving other's knowledge and skills; by encouraging participation of students who did not themselves possess equally strong academic skills; and by mediating students' access to intellectual resources. While Scardamalia's approach to epistemic agency emphasizes the activities that lead to the concrete production of knowledge, we notice that the other studies focus more on the activities that facilitate these knowledge production activities.

SHARED EPISTEMIC AGENCY

The approach to epistemic agency as introduced by Scardamalia emphasizes the aspect of advancement of the collective knowledge based on individual contributions of the community members. In our opinion, this perspective emphasizes individual cognition and its outcomes. Also Holland, Lachicotte, Skinner, and Cain (1998) maintain that epistemic agency does not reside within the individual's mind, but emerges through participation in collective activities. In the same line of thought, Emirbayer and Mische (1998) consider agency to be characterized by experience-based social participation, involving acts of negotiation on the course of future actions. Martin (2007) maintains that the achievement of common goals and productive participation with others requires more than individual strategizing. Furthermore, in a theoretical study on networked intelligence, Hakkarainen, Lonka and Paavola (2004) sketch the context wherein groups' epistemic agency occurs and develops, that being those contexts where participants engage in collaborative efforts to pursue shared, knowledge centred projects. The aforementioned studies take, at theoretical level, a collective stance on epistemic agency. However, an individual approach persists when attempting to address the concept methodologically.

In a previous study (Damşa, Kirschner, Andriessen, Erkens & Sins, 2010) we draw upon the idea of intersubjectivity (Matusov, 1996) and collective participation in the context of collaborative learning activities. We investigate these aspects in the context of the knowledge creation metaphor emphasizing the *object-oriented* collaborative knowledge creation; that is, interaction where individual students participate in collaborative learning activities *through* common, tangible objects of activity (Paavola & Hakkarainen, 2005; see also Bereiter, 2002, Stahl, 2002). The object can be a more abstract entity or a concrete object, potentially shared and jointly constructed (Engeström, 1987). In our inquiry we approach the object as the latter and maintain that efforts of learning are directed at collaboratively advancing shared objects, rather than just individually carrying out tasks or dialogic interaction. In the context of learning as proposed by Paavola and Hakkarainen (2005), shared object is the materialization of the group's knowledge, and,creation of this conceptual type of object requires epistemic agency.

The notion of *sharedness* in agency presupposes intersubjectivity and interaction between participants. It suggests, nevertheless, an established community of practice, which is not necessarily attained when groups of students work together on study assignments. Although collaborative tasks are performed, that does not necessarily involve the group being an established community with customary ways of working. We argue it is the shared object that is the reason and the focus of the collaborative activities and which brings the group members together. Stahl (2007) also emphasizes the role of the object of activity within groups as a reason for interacting, as a goal of work, or as outcome to reach. In such contexts, groups still have to negotiate ways of working together, and gradually develop their understanding about the shared knowledge object, and proceed in developing this object (Andriessen, Baker & Van der Puil, in press). Therefore, we choose to use the notion *shared epistemic agency* to denote the shared efforts of creating concrete, shared knowledge objects.

These theoretical insights indicate that there are two dimensions that could mainly characterize the concept of shared epistemic agency: the aspect of *epistemic actions* and another of *regulatory processes*. The activity theory perspective (Engeström, 1987) emphasizes the interactions between different participants who orient themselves towards the common object of activity, maintains learning as a human activity, and involves actions that are directed at specific goals; these actions are functionally subordinated to activities which aim at realizing an object. The actions are thus the intermediate and complementary steps in the direction the realization of the final object.

The first dimension is that of *epistemic actions.* These are actions that are explicitly oriented towards knowledge and realizing knowledge objects. They reflect a group's deliberate intention for knowledge creation, and also the translation of this intention into concrete acts. In the context of collaborative creation of knowledge objects, these epistemic actions are concretized in group acts that have as results a progress of the shared objects. Understanding existing knowledge, asking (clarifying) questions, discussing new ideas, creating drafts, are examples of such epistemic actions provided by, for example, studies addressing collaborative knowledge building (Scardamalia, 2002; Stahl, 2002; Mukkonen, Lakkala & Hakkarainen, 2005).

A second dimension consists of *regulative* actions. These are processes that occur at metacognitive level, which create the basis for epistemic actions. Such elements are mentioned in the studies addressing epistemic agency discussed in the previous section (Scardamalia, 2002; Hakkarainen & Palonen, 2003; Martin, 2006). Within this dimension we consider two aspects as being of importance: *shared intentionality* and *regulatory processes*. We construe intentionality as a reflection of the group intention(s) to actively engage in knowledge related collaborative activities, expressed in common goals, commitment to these goals, and negotiation and anticipation of future collaborative actions. The regulative processes we interpret as the metaknowledge that the group has with regard to the state and progress of the knowledge object, and the subsequent actions that emerge from this knowledge. Instead of relying on external instances (such as the teacher), the group members take manage the advancement of the shared knowledge object, their peers' activities and the group's activities.

The shared knowledge object is represented as the result of an epistemic endeavour. Epistemic actions are crucial for the creation of the shared knowledge object; their performance has a direct result on the advancement of this object. The regulative actions are construed as a contextual component. These processes make the occurrence of the epistemic actions possible, but are not directly related to the development of the shared object.

ANALYSIS OF EMPIRICAL SETTINGS

To illustrate this theoretical position and how shared epistemic agency is instantiated and evolves in the context of collaborative group work, we selected an example from a data set collected in the context of an explorative case study conducted in higher education. A case study approach was used. The data set was chosen because we think it actualizes aspects concerning shared epistemic agency in the context of collaborative research learning activities. The analysis of the empirical material illustrates how shared epistemic agency is instantiated during collaborative work of students on common knowledge objects.

Research Context

The *Bachelor Thesis* course is the final one in a series of research modules offered in the context of the bachelor programme in Educational Sciences. It is a 20-week course that aims at supporting students to integrate and apply their previously acquired scientific research knowledge and skills, and to develop their skills in collaborative academic writing. The course was set up according to a project-based model, in which the participants were required, in groups of two to four students, to collaboratively set up and conduct a research project and report on these research activities. The research work represented the main part of the course. In addition to the research task, students were required to write individual reflection reports, in which they analyse and reflect upon their individual learning experiences and their participation in the group work. Tutorial sessions, i.e. face-to-face meetings with the tutor – a teacher or a researcher – were organized on a needs basis. A Blackboard® facilitated students' collaboration during most of these activities. The final group product was a common research report and a group presentation of the research project, during a *Bachelor Thesis* congress day.

Case Description

The participants in this study were undergraduate students attending the course. Five project groups participated in this study and were followed intensively for the entire course period. These groups had the possibility of signing up for research topics brought in by external clients (two private training and research companies). They negotiated with their clients on the research topic, since the clients had a direct interest in using the results of the research. The groups were formed at the beginning of the course period, based on the students' interest for the research topics proposed by the clients and researchers.

In this study we use illustrative material from one of the participating groups. This group's members were part-time, one male and two female students. All three were graduates in higher professional education studies and had daytime jobs in the educational field. These students attended the same courses in the past but had never worked together on a collaborative task. The formation of the group was based on the interest in a research topic provided by one of the external clients. The topic was the use of educative games in secondary vocational education.

Data Sources and Analysis Approach

A large amount of data was collected, using qualitative methods (i.e., observations, semi-structured in-depth interviews, open-ended questionnaires, and written documents). For this chapter, we have chosen a qualitative and interpretative analytic approach, aimed at tracing activities that characterize shared epistemic agency in the empirical data.

First, a global analysis of group's activities was conducted. For this purpose, the observation of the researcher, the group's meeting minutes, the reflective reports and the pre- and post-questionnaires were globally analysed. This analysis resulted in a description of the activities the group had undertaken during their research project and during the writing of the common research report. Next, an attempt was made to identify sequences of activities that indicate the group's shared epistemic agency. Interaction analysis (Jordan & Henderson, 1995) was employed, which allows for focused examination of the identified interaction sequences. We selected episodes from the protocol that contained key events. An episode corresponds to a coherent activity sequence demarcated by the learners' own behaviour (Roschelle, 1992). A key event was considered as an event that triggered subsequent actions, which lead to a particular, relevant development regarding the shared object (in discussions, mails, object versioning, feedback). We adopted a longitudinal analytic perspective, based on the stance that different types of collaborative acts performed in situated practices are better described when investigated over time (Ludvigsen, Rasmussen, Krange, Moen & Middleton, 2010). An important note here is that the unit of analysis was not the individual input, although individual contributions remain traceable to specific authors, but units which allowed a portrayal of characteristic of epistemic agency at group level.

Integration of Findings

A global analysis of the data collected from this group indicated a number of general characteristics of the collaborative research work. What this data shows, amongst other things, is that shared epistemic agency displays the characteristics of a complex process that is initiated and evolves throughout the project period, being gradually built up in the context of the group's collaboration. Second, it appears very clearly that the group's activities were guided by work on the shared objects of activity, represented by the group's research report. Observations also revealed that the process of conducting a collaborative research project and writing a scientific report was an iterative process, which results in a gradually-evolving knowledge product. This process involved ideas that are developed, redeveloped, revised, re-written, and maybe revised again. Any step made in the direction of the final product was defining for shape, content and quality of this product. Sometimes students must go back to previous steps and products, adjust them and restart the process. However, the sequenced activities were intertwined and in many situations students split tasks and, while one student or a sub-group elaborated on a sub-product and finished it, the others worked on other sub-products.

Furthermore, the study also indicated that this type of collaborative long-term research project required students to develop skills and strategies that support such an epistemic endeavour. The process analysis allowed us to conclude that the group developed work strategies (or adapted old ones) that were beneficial for creating and advancing the shared knowledge objects, but also for good collaboration within the group. For the first aspect, students applied strategies such as intensive discussions of literature, research methodology or statistical analysis approaches, in order to develop shared understanding of the concepts they were operating with. They used different writing strategies, such as separately writing report sections and discussing them afterwards, but also synchronous collaborative writing, which involved group members sitting together behind one computer, discussing and typing at the same time. Redrafting was used, which involved repeated restructuring and improvements of the produced version, normally based on feedback of the other group members and on evaluative discussion. Other strategies were giving feedback on drafts produced individually, and distributing (knowledge) resources, which involved sending articles or other informative texts through e-mail or uploading them on the shared group's space. These types of activities we associate with the first aspect of shared epistemic agency, the *epistemic actions*. For the second aspect, project management strategies were employed, such as joint planning, coordination and monitoring of object-oriented activities and of group activities, regular communication (face-to-face or using technological support), or moments of individual and group reflection. Some of these group activities can be listed under the category of *regulatory processes*, as they are described in the previous section of this article.

Instances of Shared Epistemic Agency

In the following section we discuss three excerpts extracted from the group's discussion protocols and the final interview. These excerpts are used as illustration of the analysis approach we used in this explorative study. They are not meant to demonstrate the full-scale phenomenon, but are meant to illustrate different actions (whether epistemic or regulative) that characterize shared epistemic agency, which become visible at various moments in the collaborative process.

The initiation of the research project involved choosing a research topic and agreeing with the client upon the end product to be delivered, in addition to the research report. The first (intermediate) object to work on was a research plan, in which the group specified the research goals, research questions, and to provide a theory-based account for the topic and research approach the group had chosen. When the research plan was approved by the tutor and the client, the group could continue their project.

The group started by collecting information about the chosen research topic, which was the use of gaming in secondary vocational education. Since the group members were not familiar with the concept of gaming there was much need of getting informed about the topic. One of the group members created an online platform, which was used as virtual work space for uploading the gathered articles and materials, placing announcements, making joint appointments, storing the drafts of the produced objects, etc. This action is relevant evidence of the group *sharing knowledge resources*, which we considered a characteristic element of shared epistemic agency. The gathered information was discussed in weekly face-to-face meetings. In the third project week, the group decided to start the work on the actual object: the research plan. The excerpt below shows a fragment of a discussion where the group tries to tackle formulation of the research question(s).[1]

Excerpt 1.

1. **Lisa:** Is it possible to brainstorm on the research questions this evening?
2. **Ellen:** Yes, it seems a very good idea.
3. **Lisa:** It's funny, I was reading those articles you sent […]. That research is on a game IT emperor, I actually don't know what that is. That gave me ideas, we could investigate a game, so…
4. **Theo:** Yes, what are the obstacles when playing, that is a research question.
5. **Ellen:** Which factors …

6. **Lisa:** Wait a second, do we have to formulate a main question too?… Because I didn't really understood that; by the methodology the questions types were used wrongly all the time. Everybody calls them research questions. I've got the idea that we make the same mistake. Don't we have to clarify this before formulating the questions for our research?
7. **Ellen:** Yes, you are right, this must be clear for the three of us.
8. **Lisa:** In any case, you have the main question and underneath…
9. **Ellen:** … you have the research questions. So, main question in detailed research question. It is actually an itemization.
10. **Theo:** And that one you operationalize, in questionnaire questions, for example.
11. **Lisa:** So, do we need to have a main question as well? Or do we have one already?
12. **Theo:** Of course we need one.
13. **Lisa:** What could an educative game add to the learning process and to the motivation? Something in this direction?
14. **Theo:** Yes, how can …
15. **Lisa:** … what can an educative game add to the learning process and to the motivation of students in vocational education?

(Group discussion, 3rd project week)

This excerpt shows an example of a combination of epistemic actions, which we identify as *gaining shared understanding* on the research methodology, and *creating and negotiating new ideas*. The meeting was organized specifically to start work on the intermediate object: the research plan. However, the excerpt shows that the group encountered some obstacles in immediately creating this object. During the discussion, the group came to realize that they did not have a clear and common idea about the types of questions to be formulated in a research plan, and about how the research questions must be formulated. Therefore, the group deliberately decided to dedicate a part of the discussion to clarifying and creating shared understanding of the methodological concepts to be applied when creating the research plan. We consider developing shared understanding as a relevant epistemic action that characterizes shared epistemic agency. The discussion fragment indicates that the group members were aware of the fact that they must have a shared understanding of the concepts they must apply before factually acting for developing the knowledge object itself. We construe this as an action characterizing shared epistemic agency because it expresses the group's deliberate efforts to gain this shared understanding of conceptual aspects, which creates the premises to continue the work on the shared knowledge object.

Furthermore, the excerpt shows that group members, after agreeing upon the way the question should be formulated, proceeded with producing and exchanging ideas concerning the content of the questions. They formulate various versions of the questions, based especially on insights gained from the literature and the observation of the educational practice. This process of idea generation and negotiation also indicates the group's intentions to create a shared object, which integrates all members' ideas and insights.

While the excerpt presented above illustrated activities at epistemic level, in the following section we discuss two excerpts that designate aspects of shared intentionality and regulation of the group's object-oriented activities, as they are described in the previous section of this article. This excerpt is extracted from a discussion held three weeks after the research questions were formulated and one week after the research plan received a 'go' from the tutor and the client. This fragment ends a face-to-face discussion in which the group started to think about the design of data collection instruments. At the end of the discussion the group agrees upon activities to be conducted in the coming week.

Excerpt 2.

1. **Ellen:** And now the tasks for this week … Lot will work on the questionnaire.
2. **Lisa:** I'll make a concept for the questionnaire. The actual questions … I don't know… […]
3. **Theo:** Yes.
4. **Ellen:** It will be ok if you make a concept, otherwise we will muddle all the time.
5. **Lisa:** Ok, but I don't know if I can generate concrete questions …
6. **Ellen:** That is all right, maybe you can sketch some dimensions ... and based on those I will try to figure out some topics for the interview?
7. **Theo:** And the questionnaire questions in statement form, with the answers agree/disagree.
8. **Lisa:** Yes, and you take care of the statistical part later …
9. **Ellen:** And reserving a room for next week. So, we have enough to do before the next meeting.
10. **Theo:** Yes, then next week we discuss all the produced pieces; if you want any feedback before the meeting, you can upload it on the platform, so we can read it in advance. It's quicker that way.

(Group discussion, 6th project week)

This discussion fragment shows that the intermediate objects to be produced by the group (data collection instruments) are divided between the group members. From the perspective of the theoretical framework described in the previous sections, this activity can be labelled as *coordination of object-related group activities*, a regulatory process that, in our view, characterizes shared epistemic agency. Each of these objects is to be written individually, but the discussion indicates that each group member is aware of the object-related activities to be performed by the other group members. Also, the work on one intermediate object (the interview topic list) depends on input provided by another group member. So, although these objects are produced individually, the object-related activities performed by the group members are intertwined and coordinated, as this above fragment showed.

In the following excerpt a fragment is shown of the interview with the group at the end of the project period. The content of this excerpt is related to the previous examples, since the group answers the researchers question about how the coordination activities described above.

Excerpt 3:

1. **Researcher:** How did you organize these activities related to the making of the object?
2. **Theo:** We agreed that we work on drafts separately, after we discussed the topics and ideas during the meetings; we noticed quickly that this way works well for us. And that we must critically evaluate each others' products.
3. **Lisa:** And that we would analyse and evaluate the content. I had the feeling that, yes, I have made this, it is my vision, but it can change and it can become better if it is combined with the others' ideas. […]
4. **Ellen:** The feedback we gave was always content or object related, never personal. […] We agreed at the beginning of the project to plan who will work on what and when that part should be ready, in order to make it possible for the others to give feedback.

(Group interview, end of the project period)

This excerpt shows that the groups deliberately chose the strategies they applied, of dividing sections of the shared object to be produced individually and then to discuss them with the other group members, since they realized this best fits their work style. Another reason group members pointed out during the interview was the fact that having concrete drafts helped them to conduct focused discussions on the development of the object. In this way they were enabled to give object-bound feedback and to make rapid progress in developing this object. This additional fragment of the data indicates that the coordination of group activities serves the purpose of creating shared objects, and it was not simply an activity that occurs during the collaboration process.

DISCUSSION

We started this chapter by asking what aspects of shared epistemic agency can be identified in existing scientific literature, and what types of activity characterize shared epistemic agency in the context of collaborative design activities of small groups of students. To gain more insight in the way epistemic agency is described in theoretical and empirical studies, we proceeded with a brief review of literature.

At theoretical level, we distinguished three concepts that are seminal when explaining and elaborating the shared epistemic agency construct. First, it is the agentic element, which points at the capacity of humans to determine and steer (the direction of) their actions. We interpreted and applied this aspect in the specific learning context we analyse by searching for elements of (shared) intentionality in learners' actions (Bandura, 2001). Second, we emphasized the epistemic aspect of agency. Drawing upon ideas put forward by Scardamalia (2002) we elaborate on this aspects from a learning process perspective, which involves the idea of knowledge and knowing, and learners actively pursuing means and activities that bring about knowledge advancement. Finally, the aspect of intersubjectivity (Matusov, 1996) we related to agency by looking at learners' sharedness in actions. This aspect is essential for understanding the shared epistemic agency construct, since sharedness is the particular characteristic that encompasses the capacity of a group to act jointly in their work on knowledge objects.

Based on the theoretical insights, we developed the notion that shared epistemic agency consists of two main aspects: epistemic actions and regulatory actions. The analysis of qualitative data from a case study provided input for identifying collaborative research activities that fit the framework specified when describing these aspects. The first dimension, epistemic actions, was described as consisting of actions such as developing shared understanding, joint generation of ideas, shared object development, and shared resource management. The intentional aspect within the regulative dimension is illustrated by actions such as setting common goals and making joint plans of action. The regulatory processes were illustrated by actions of monitoring and coordinating object-related actions.

This chapter examined shared epistemic agency in the context of groups' collaborative work for developing a shared knowledge object as a specific instance in which knowledge creation can occur. We need to emphasize that the framework that has been created is intended as a basis for further examination and not an exhaustive description of the concept of shared epistemic agency. In terms of the former, this framework represented a functional starting point when approaching the empirical data. One aspect in which this framework shows its appropriateness can be referred to as the shared nature of epistemic agency. The results showed that the shared knowledge object consists of, for the students, the common focus point and creates the premises for joint actions because they feel responsible for developing it; and it was identified in the extent to which the students were engaged in advancing this knowledge object as best as they could.

In the current study, characteristics of shared epistemic agency occurring in the context of collaborative work were identified. The study indicates that shared epistemic agency is a characteristic of groups that develops and evolves over time. The analytical approach applied in this study provided an insight into the activities that are relevant for shared epistemic agency, but also, to a lesser extent, into how they relate to the advancement of the knowledge object or into the possible changes in agency during the collaborative work. In Hakkarainen's (2006) terms, agency also appears as an ontological growth, which might be registered in terms of qualitative changes that occur in students' learning and collaborative behaviour between work sessions, when engaging in long-standing, personally meaningful study projects around shared objects of activity. Refining this preliminary framework and addressing shared epistemic agency from a longitudinal perspective (Ludvigsen et. al., 2010) could represent the starting point for subsequent studies when trying to examine such potential qualitative changes.

CONCLUSION

This explorative case study attempted to gain a better understanding of the concept of shared epistemic agency and to examine the occurrence of activities that characterize shared epistemic agency in the context of small group research activities. The concept of shared epistemic agency was addressed in relation to the trialogical approach to learning (Paavola & Hakkarainen, 2005). This approach emphasizes the importance of creation of knowledge in collaboration in the context of object-oriented learning activities; and shared epistemic agency is considered an essential quality of groups engaged in this process. Two main dimensions of shared epistemic agency were identified – epistemic and regulative – and a number of activities characterizing these aspects were pinned down, based on an explorative analysis of empirical data.

The theoretical concepts and the analytical approach introduced in this chapter should not be seen as exclusive position or stance but as a set of resources to improve the understanding of the processes involved when shared knowledge objects are created in collaboration. Further understanding of how to fine-tune the theoretical framework and the analysis are necessary steps before heading to another phase of research, which could concern capturing the development in shared epistemic agency.

NOTE

The transcripts are originally in Dutch. Below each excerpt information is displayed regarding the type of data the excerpt was selected from, and date or period of data collection. The brackets […] indicate short sections (maximum of three sentences) of the original text that have been omitted.

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ANDREA KÁRPÁTI AND HELGA DORNER

12. DEVELOPING EPISTEMIC AGENCIES OF TEACHER TRAINEES – USING THE MENTORED INNOVATION MODEL

INTRODUCTION

Developing the epistemic agency of teachers and trainees to become reflective practitioners is a focus of modernizing teacher education in Hungary. This initiative aims at encouraging future educators to collaborate in professional teams in order to identify new professional challenges and realize innovative teaching programmes. Inviting them into international educational research projects – such as KP Lab – as active agents could contribute to establishing research-based teacher training and teachers' professional development in Hungary (Csapó, 2007).

The current study attempted to gain a better understanding of the concept of 'epistemic agency' through investigating the role of the mediating agent (mentor) and the knowledge building discourse in collaborative teacher training scenarios. As opposed to studies relying on qualitative research traditions, such as the ethnographic analytic approach, we experimented with quantitative tool development. Based on the tenet that agency represents growth of an individual's (or group's) intellectual, social and affective inventory of acting in problem-solving situations, we relied on the individuals' reflections on their own sense of advancement (instead of the researcher's analysis of collaborative dialogues) in mapping satisfaction with their self-perceived advancement. Accordingly, in this study, teacher trainees' self-perceived advancement and their satisfaction with the learning experience are considered as relevant indicators of epistemic agency. Results revealed that knowledge building discourse among teacher trainees facilitated by the mentor as a mediating social agent in collaborative activities has a direct impact on participants' satisfaction and learning success in teacher training scenarios and, thus, influences their evolving epistemic agency.

KNOWLEDGE BUILDING AS THE THEORETICAL FRAMEWORK

The knowledge-building approach (Scardamalia & Bereiter, 1993) is a hallmark in the freshly-emerged conceptions referring to social mediation as participatory knowledge construction (Salomon & Perkins, 1998). The knowledge building theory in which the present study is grounded emphasizes knowledge creation in collaboration while engaged in activities around shared objects. In this context, information and communication technology (ICT) tools are employed to catalyse

A. Moen, A. I. Mørch, S. Paavola (Eds.), Collaborative Knowledge Creation: Practices, Tools, Concepts, 219–232.

paradigm change from individual to collective knowledge creation practices. According to Hakkarainen (2009), Scardamalia and Bereiter produced a framework that has for a long time been the source of inspiration and point of reference among experts and practitioners of innovative education worldwide. This is not without reason, he claims, since the knowledge building framework managed to grasp the important elements of engagement with knowledge in order to improve the quality of education in general.

Scardamalia and Bereiter (1993) contrast knowledge reproduction strategies and knowledge building strategies. Knowledge reproductions bear limited potential for knowledge advancement and for the development of understanding on which the latter is centrally focused. It is based on 'copy-delete mechanisms', meaning that learners only retain those schemes and concepts that are 'judged to be important' (Scardamalia & Bereiter, 1993, p. 37), and delete those that are considered to be superfluous. Scardamalia and Bereiter extend the copy-delete mechanisms with the 'knowledge telling' mechanism of writing which is basically a form of reproducing information. They proclaim that these two parallel mechanisms support the 'low-profile work with knowledge' and are examples of the transmission model (p. 37). In this model, presentation, recitation and the dialogic question-asking are the prevailing methods that are used in classroom practice.

As opposed to this model, knowledge building proposes a form of learning that is based on a process aiming at more coherent understanding. Scardamalia and Bereiter (2006) suggest treating students as members of a knowledge building community rather than learners or inquirers. According to their view, effective knowledge creation results in the development of the actual community's knowledge. The knowledge building process is centred on 'conceptual artefacts' i.e. entities that support further knowledge advancement (Bereiter, 2002). Hence, knowledge building pedagogy means that creative knowledge building can be maintained in the classrooms where learners are active agents in the community's joint knowledge work.

KNOWLEDGE CREATION THROUGH COLLABORATION AND KNOWLEDGE BUILDING DISCUSSION

In the knowledge building pedagogy, discourse better suits the process of knowledge advancement and collaborative problem solving than argumentation that is currently promoted in education (Scardamalia & Bereiter, 2006). There are weak and strong versions of identifying the role of knowledge building discourse. According to the former version, knowledge transformation is reflected in the discourse, while the latter claims that 'there is no advance of community knowledge apart from the discourse' (p. 103). Knowledge building discourse is, thus, discourse 'whose aim is progress in the state of knowledge: idea improvement' (p. 103).

Knowledge building discourse can be put into three categories: (1) focus on problems and depth of understanding; (2) decentralized, open knowledge environments for collective understanding; and (3) productive interaction within broadly conceived knowledge building communities (Scardamalia & Bereiter, 2006). The first category underlines the fact that, in the process of knowledge building, focus is on problems (rather than on categories of knowledge). The second category refers to decentralized, open knowledge building with a view on collective knowledge. This process involves complex interactions that aim at engaging the participants, distributing work within the group, sustaining inquiry, and monitoring advances. More and less knowledgeable members are both essential to group functioning. As for the third category, they give the example of the peer review process for scientific publication in which one works with 'ideas in contexts broader than one's immediate working community' (Scardamalia & Bereiter, 2006, p. 275).

MENTORING COLLABORATION AND KNOWLEDGE BUILDING PROCESSES

Productive interactions that result in knowledge creation and active learning processes do not automatically occur (Berge, 1999; De Smet, Van Keer & Valcke, 2008; Dillenbourg, 1999; Liaw & Huang, 2000; Northrup, 2001; Rourke, 2000), neither does collaboration automatically produce learning (Dillenbourg, 2002). De Smet et al. (2008) stress the need for guidance and structure (Bonk, Wisher & Lee, 2004), scaffolding (Lakkala, Muukkonen & Hakkarainen, 2005; Pifarré, 2007), and facilitation as potential factors influencing evolving interactions. Thus, the role of mentors offering guidance and moderation in discussion is vital.

However, simply providing a learning environment equipped with ICT where future teachers can interact does not necessarily guarantee successful cognitive engagement and collaboration. Hence, the Mentored Innovation Model (MIM) was integrated in the instructional context, which heavily relied on knowledge building discourse (Scardamalia & Bereiter, 1994) in collaborative knowledge creation processes where development of epistemic agency was addressed.

Mentoring is referred to as a hierarchical relationship where expert-to-novice transfer is processed (Hew & Knapczyk, 2007; Kram, 1983; Le Cornu, 2005; Levinson, Darrow, Klein, Levinson & McKee, 1978; Murphy, Mahoney, Chen, Mendoza-Diaz & Yang, 2005). However, there has been a tendency of re-conceptualizing this process (Le Cornu, 2005). A shift from the hierarchical, one-to-one, expert-to-novice transfer to mentoring as a reciprocal and mutual process has emerged (Bona, Rinehart & Volbrecht, 1995; Jeruchim & Shapiro, 1992).

Le Cornu (2005) argues that a mentoring attitude that is involved in this type of complementary relationship underlines the importance of growth experienced by both parties. Mullen and Lick (1999) refer to synergistic co-mentoring that, similarly to Le Cornu's interpretation, stresses the reciprocity element. Kram and Isabella (1985) claim that mentors have two major responsibilities towards their protégés: psychosocial and instrumental. In teacher training, 'psychosocial responsibilities' refer to elaboration of professional expectations and outcomes and encouragement of teaching practices and standards (Ensher, Heun and Blanchard, 2003). 'Instrumental responsibilities' involve direct support such as modelling teaching methods, direct feedback and providing access to resources.

In teacher training and teachers' professional development as well (with reference to the target population of the present study), the view on mentoring has included learning communities that enable supportive interpersonal relationships which enhance in- or pre-service teachers' professional growth (Dorner, 2012). McLaughlin (1997) argues that in such communities they 'learn new practices and unlearn old assumptions, beliefs and practices' (as cited in Le Cornu, 2005, p. 356). In such communities, the expert-novice transfer and the hierarchies attached to it are reduced (Lieberman, 2000). With the emergence of ICT, interaction between mentor and mentees, participants of the synergistic mentoring process can be maintained at any place and time that is convenient to them.

EVOLVING EPISTEMIC AGENCY AND THE MIM

Knowledge building discourse results in refining and transforming ideas and knowledge through discussion and interaction in the community. Epistemic agency manifests in the individual and collective responsibility for knowledge advancement and professional development of community members. This involves the process where 'expertise' is construed as part of the knowledge building principles that are described by socio-cognitive dynamics, such as negotiating a fit between ideas, using contrasts to sustain knowledge advancement, dealing with motivation, evaluation and long-term planning (Scardamalia, 2002). These are normally considered the tasks of teachers.

In the MIM, collaborative knowledge building is viewed as learning theory, pedagogical theory and even pedagogical strategy (Dorner, 2012). Members of teacher communities learn from each other because they engage criticality, adaptation or adoption of resources in online mentoring scenarios which trigger specific learning mechanisms. When mentoring is successful, individual cognition is encouraged in peer interaction: interaction among participants generates extra activities (explanation, disagreement, mutual regulation), which trigger extra cognitive mechanisms (Dillenbourg, 1999, 2002; Dorner, 2012; Dorner & Major, 2009; Dorner & Kárpáti, 2010; Kárpáti & Dorner, 2008).

Knowledge building discussions – when carefully monitored and analysed – can provide for authentic 'collaborative moments' in teacher education. The task of mentors in guiding and facilitating these discussions is to achieve certain learning or communicative goals. In this context, classroom discussions are perceived as a means for trainees to express their ideas and thoughts and negotiate meaning among themselves and between them and the mentor. Teacher trainees in their communities participate in inquiries at the frontiers of knowledge. Their activities with online mentors can be characterized as a transformative communication for learning (Kárpáti & Dorner, 2008).

THE ELTE CASE: MEDIATING GOOD PRACTICES THROUGH THE MIM

At the Eötvös Loránd University (ELTE), the MIM was employed for mediating good practice in teacher training scenarios involving trainees of English as a

Foreign Language (EFL). Mentoring events in blended learning courses are organized so as to initiate novices to a professional culture, and create or share artefacts through interactions with peers and experts. These events encompass the following features of the MIM: (1) identification of pedagogical and methodological issues; (2) creation of a joint research agenda and development plan (within the small groups); (3) provision of professional support in the form of mentored training (mentoring by mentors); (4) mentoring and innovation processes are intertwined (innovation referring to innovative ways of applying technology in EFL classrooms); (5) cognitive tools are applied; and (6) dissemination in this case is done at study-group level (Dorner & Kárpáti, 2010). It also involves role modelling: the roles of the practising teacher (teacher trainer), educational researcher and the educational policy maker are modelled for trainees, who follow the process of making curricular decisions, planning for authentic teaching and learning processes, collecting, creating or adapting digital and traditional teaching aids (Dorner & Major, 2007, 2008, 2009).

In the light of the above, the pre-defined instructional aims, which according to Strijbos, Martens and Jochems (2004) belong to the category of ‘open skills’, included the following broadly formulated items: students should have the opportunity to (a) become aware of their own beliefs and attitudes to education and recognise alternatives; (b) get to know theories of online communication and collaboration; (c) discuss and argue about theories; (d) apply theory in realistic situations; (e) discover and try out the communication and collaboration possibilities offered by the online platform; (f) experience small-group collaborations; (g) acquire and develop skills and procedures relevant and inevitable in this working mode; and (h) give reflective feedback on the online mentoring process and on the mentors’ contribution (Dorner & Major, 2009).

The groups of teacher trainees collaborated in problem-solving scenarios where object-related activities involved authentic English language usage and simulated teaching practices of EFL supported by ICT. In the pedagogical settings, during implementation of shared objects (that were frequently identifiable with the course artefacts) conceptualization and advancement of the communities’ pedagogical practices were the focus, with special attention to evolving epistemic agency.

Online collaborations were organized in small groups around knowledge and/or course artefacts, such as digital learning materials and lesson plans, so that growth of the intellectual, social and emotional inventory is used in complex problem-solving activities in which participants’ epistemic agencies are being evolved. The usage of online communication tools for small groups aimed at supporting ways of creating collaborative agencies. The design work and the implementation of learning resources required highly reflective behaviour related to the traditional learning practices and providing constructive feedback. The trainees’ ‘private’ ICT use also had to be enriched by pedagogical practices related to ICT use in education. The blended set-up (including face-to-face meetings and online sessions) in the scenarios was supposed to provide for the reflective discussions by using communication tools in the computer-supported environment. Group discussions focused on the know-how of implementing different learning resources and also negotiations about the usage of ICT in EFL settings. However, any initiative for broadening the discussion topics was welcome.

The modules were constructed of well-structured and ill-structured activities respectively (Strijbos et al., 2004) as follows (Dorner & Major, 2009):

1. Introduction to the topic of the module (e.g. reading a short, motivating text) – well-structured activity
2. Online discussion of first impressions (e.g. collecting pros/contras of a method) – ill-structured activity
3. First readings – well-structured activity
4. Open-ended questions to discuss within the group (one group member responsible for opening and closings i.e. kick-off and summary of the main arguments/ideas collected jointly) with the e-moderator 'present' in each thread – ill-structured activity
5. Discussion forum/wiki exclusively for creating the group product – ill-structured activity
6. Evaluation of the group-product, peer-evaluation, self-evaluation.

The ELTE methodology cases were carried out as an addition to the established, rather rich curriculum of the course (topics of ELT methodology, microteaching, observation, etc.). The students processed modules (coherent task series) on the online platform on methodology-related topics, which were not dealt with during F2F sessions. However, the aim was to maintain an effective combination of enhancing blends and transforming blends. Enhancing blends do not radically change the form and methodology of learning and teaching, as used to occur without the online component, and they encompass additional resources and supplementary materials added to the curriculum. Transforming blends allow for radical transformation of the pedagogy in use, which provides for activities in which learners are engaged in an intellectual activity that was not possible without the technology (Graham, 2005).

Each study group was divided into three to four smaller groups of 4 to 5 students, since, from a research point of view, collaboration and interaction in small groups are more traceable, and intersubjective learning, knowledge building and the formation of group interactions are more observable (Stahl, 2003).

The described pedagogical set-up was designed along the idea of boundary crossing so as to allow for cross-fertilization of various knowledge practices. The pedagogical setting itself including an experienced teacher trainer, the pedagogical researchers allowed for boundary crossing and cross-fertilization where teaching and learning practices related to domains: EFL for special purposes (argumentation, methodological advancement); ICT in teacher training; and ICT in EFL teaching and learning processes. Creative collaboration in the groups provided for possible spontaneous cross-fertilization processes. The VLE supported flexible tool mediation: a Moodle environment, which was utilized for monitoring the knowledge-building processes and the transformation of individual to collaborative knowledge practices through networked activities.

RESEARCH HYPOTHESES, FOCI AND METHOD

We assume that the creative collaboration of groups of teacher trainees, a teacher trainer and the pedagogical researchers fosters the crossing of boundaries between representatives of the Hungarian higher educational scene at different levels. The present pedagogical scenarios allow for both the integration of technological tools within teacher training and the development of trainees' epistemic agency – i.e. allowing them to author themselves and their knowledge practices and to take responsibility for their own knowledge advancement (Scardamalia, 2002).

Central to the transformation of individual and collaborative knowledge practices that take place in creative collaborative activities around shared objects is the knowledge building discourse. In relation to the collaborating parties' satisfaction with the mentoring events that aimed at generating the growth of the participants' resources for acting responsible for their knowledge advancement and relying on their own cognitive, social and affective inventory so that they will be able to overcome challenges within an ICT retooled environment (i.e. developing epistemic agency), we focused on defining the position of online communication – the knowledge building discourse – in the mentoring model. According to our hypothesis, in the MIM, the online communication – knowledge building discourse facilitated by the mentors connected to creative collaborative activities – results in evolving epistemic agency that is characterized by experience-based social participation. Thus, an explanatory model that defines the position of online communication in the mentoring processes can contribute to the analysis of the complex process of developing epistemic agency.

Based on the idea that agency represents growth of an individual's (or a group's) intellectual, social and affective inventory of acting in problem-solving situations and overcoming difficulties in social networks, we relied on the individuals' reflections on their own sense of advancement and developed the Participant Satisfaction and Communication Questionnaire (Dorner, 2007). In the MIM, in which developing teacher trainees' epistemic agency was addressed, data on their perceived development and satisfaction with the learning experience are considered as a relevant source of data provision, and an indicator of agency.

Participants included teacher trainees divided into four different groups in three successive semesters (n = 76). Pedagogical scenarios were hosted in a Moodle environment, which was used for sharing knowledge practices, leading collaborative discourse and creating course artefacts.

An adjusted version of the questionnaire was used in evaluation and validation process of the European CALIBRATE project, where in-service teachers worked in collaboration with their colleagues, pupils, mentors and educational researchers within the framework of introducing the European Learning Resources Exchange (Dorner & Kárpáti, 2008, 2010; Kárpáti & Dorner, 2008).

In the questionnaire, those items were adapted that were considered to be relevant in the present pedagogical scenarios as regards the experiential information about the respondents' satisfaction with the mentors' performance, their perceptions of the mentors' and their group-members' social presence, and their perceptions of the interactions around shared objects, which all have relevance for the socio-cognitive dynamics of epistemic agency. The items concerning social presence were adapted from social presence scales employed by Gunawardena and Zittle (1997), Picciano (2002), Richardson and Swan (2003), and Swan and Shih (2005).

Based on the previous test sessions in the CALIBRATE project, the questionnaire concentrated on the following elements of the mentoring model: participants' global satisfaction, the mentors' role, online communication around shared objects and the participants' perceived social presence. Respondents were asked to consider their ratings in the context of the online mentoring events and rate their agreement (on a 4-point Likert scale) with statements concerning the above-mentioned variables.

RESULTS AND DISCUSSION

Satisfaction with self-perceived development that is considered as an indicator of epistemic agency was explored by relying on the subjective values provided by the participating respondents. During the analyses, dependent variables that quantify respondents' perception of the mentoring scenarios and independent variables were created. In the first phase of the regression analysis, we focused on investigating the extent to which the independent variables affect the dependent variable.

The following procedure was carried out in the case of all the four variable groups referring to the constituents of the model. The 4-scale ratings were converted to a 0–100 scale to yield single scores for each variable. Regression analyses were computed and significant items were indicated – with the respective importance values. On the basis of the importance values, global indexes were calculated referring to the four constituents. In the second phase of regression analyses, we employed these indexes (Dorner & Kárpáti, 2010).

We found two variables to have significant impact on the *participants' global satisfaction*: *benefits* (affective rather than cognitive nature) (imp. .46), the *experience gained by participating in the mentoring events* (imp. .28). Regarding the evaluation of the *mentors' role,* two variables showed significant impact: *feedback provided by the mentor* (imp. .66) and the *help offered by the mentor* (imp. .18). In respect to the perceived *social presence* two variables proved to be significant: *distinct impressions of the mentor were created* (imp. .53) and *distinct impressions of the group members were created* (imp. .11). The following three variables proved significant on the participants' satisfaction with the online communication around shared objects: *feeling comfortable with participating in the online discussions* (imp. .15), *individual opinions acknowledged by group members* (imp. .13) and *feeling comfortable conversing with the mentor through the online surface* (imp. .17) (Table 12.1).

Table 12.1. The results of the survey on the components of the mentored innovation model

Components of the model	*Beta*	*DF*	*F*	*Significance*	*Importance after transformation*	*Importance*
Participants'global satisfaction ($R^2 = .74$)						
'benefits gained'	.39	3	24.15	p = .000	.38	.46
'usefulness of experience'	.58	3	53.33	p = .000	.62	.28
The mentor's role ($R^2 = .84$)						
'mentor's feedback'	.42	2	8.32	p = .000	.76	.66
'help provided by mentor'	.64	2	14.60	p = .000	.21	.18
Social presence ($R^2 = .64$)						
'distinct impressions of mentor were created'	.69	3	54.97	p = .000	.82	.53
'distinct impressions from group members were created'	.20	2	4.74	P < .012	.17	.11
Online communication ($R^2 = .57$)						
'participating in online discussions'	.27	2	6.73	p < .003	.27	.15
'individual opinions acknowledged by group members'	.26	1	6.93	p < .011	.23	.13
'conversing with the mentor through the VLE'	.44	3	16.03	p = .000	.51	.29

Setting up the explanatory model that defines the position of online communication (knowledge building discourse) in relation to participants' satisfaction was carried out in the second phase of the regression analyses.

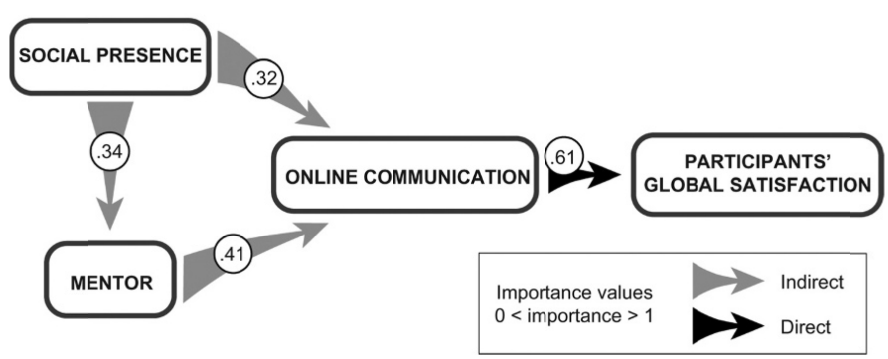

Figure 12.1. Representation of the explanatory model with the mentored innovation model.

In the first circle of analyses we investigated the constituents' impact on the participants' global satisfaction. We found that online communication has the strongest direct and significant impact on the participants' global satisfaction ($p < 0.000$; imp. .61). Satisfaction with the mentor's performance ($p < 0.000$; imp. .41) and perceived social presence of the participants ($p < 0.000$; imp. .32) have an indirect impact on the online communication in the mentoring process; an indirect impact between the latter two elements was also depicted, however the cause-effect relationship was difficult to establish (Figure 12.1).

Table 12.2. The explanatory model: the position of online communication in relation to participants' satisfaction with the learning experience

Components of the model	*Beta*	*DF*	*F*	*Significance*	*Importance after trans-formation*	*Importance*
1st step: Course satisfaction as dependent variable ($R^2 = .62$)						
Online communication	.79	1	115.39	p = .000	1	.61
2nd step: Online communication as dependent Variable ($R^2 = .73$)						
Social presence (independent variable)	.43	1	23.24	p = .000	.44	.32
Mentor's role (inde-pendent variable)	.53	1	34.71	p = .000	.56	.41
3rd step: Mentor's role as dependent variable ($R^2 = .34$)						
Social presence (independent variable)	.60	1	28.25	p = .000	1	.34

Thus, we can only assume that the successful mentoring influenced favourably the participants' perceived social presence of the mentor and their peers.

Perceived Cognitive, Social and Affective Growth as Indicators of Developing Agency in the ELTE Mentored Innovation Model

In the present study, the online communication (knowledge building discourse) had a direct and significant impact on the participants' satisfaction with the learning experience. Statistical analysis supported the assumption that interacting with peers and the mentor in creative collaboration, which aims at developing epistemic agency, plays a crucial role. The mentoring model was designed so that mentors in their position as online instructors can act more like consultants and resource providers (Berge, 1995; Hootstein, 2002) rather than the exclusive source of knowledge and evaluators as in a more traditional pedagogical setting. According to our thesis, developing and utilizing this mentoring method and 'instructor attitude' allow for a more creative collaboration and collaborative knowledge building through interaction around shared objects within the micro communities and reduce the rigid forms (one-directional flow) of knowledge creation that centres on the instructor. With regard to the need to provide for and maintain knowledge building discourse, our hypothesis was supported, since respondents felt comfortable with participating in the online discussions; they felt that group members acknowledged individual opinions, and mediation through the online surface was also effective. Interestingly however, the participants' satisfaction with the self-perceived knowledge advancement did not provide robust enough results. By identifying the subcomponents of the online communication and social presence constituents of the mentored innovation model, only indirect evidence was found that epistemic agency was co-developed, since participants assumed only limited responsibility for the advancement of their knowledge and inquiry. In our view, this can be accounted for by the fact that mentoring events which focused on collaboration with peers and co-development of epistemic agency through knowledge building discourse differed to a great extent from the teaching and learning models participants have experienced so far. As indicated previously, mentoring has been traditionally viewed as a formal process: a hierarchical, one-to-one, expert-to-novice relation where reciprocity and mutual relations were rarely used. Consequently, knowledge gained in communities where the freshly emerged synergistic co-mentoring settings prevail is less identifiable and rateable for those who have been socialized according to intellectual traditions, which are based on individual knowledge creation processes. The role of the mentor in the knowledge advancement and the attitudes connected to it are also novel to most of the participants, since the mentors' presence has been associated with direct guidance and exclusive point of reference in the teaching and learning processes rather than with scaffolding and facilitating-mentoring actions.

Perceptions regarding the social or affective dimension of the learning experience and the co-development of epistemic agency demonstrated more satisfying results. Participants were satisfied with the benefits gained in the process, the help provided by the mentor and the way she/he accepted their point of view. On the basis of their perceptions, they managed to create distinct impressions of both the group members and the mentors. These results provide support for the thesis that the mentors aimed not only at the pedagogical and or instructor role but also attended to their social responsibilities (Hootstein, 2002). However, the importance value of the strongest variable in the variable group concerning social presence implies (*distinct impressions of the mentor were created* [imp. .53]) a strong online mentor presence, and the substantive difference in the importance value as compared to the other variable (*distinct impressions of the group members were created* [imp. .11]) suggests that the participating trainees' attention was more focused on their instructors rather than on their fellow group members. This also supports the above-described explanation that teacher trainees in the present setting were predominantly accustomed to a hierarchical structure of relations and direct guidance rather than assuming responsibility for the advancement of their own knowledge and inquiry.

As for the consequences regarding the methodology of the study, quantitative data analysis (results of the data analysis of the participants' perceptions of their own advancement and judgement of the learning experience) is to be supplemented by qualitative data analysis (analysis of the knowledge building discourse that can make knowledge creation processes more visible and accountable) so as to create a more detailed description of knowledge advancement and development of epistemic agency in the mentoring events.

In this chapter, an example of the use of ICT-based mentoring events used in teacher trainees' professional development was offered. Teacher trainees confronted trainers and mentors in virtual learning environments. Moodle was successfully integrated in the training programmes and resulted in retooling boundary-crossing events where artefacts were designed or adapted and shared in real classroom setting. In the ELTE communities, by identifying the subcomponents of the online communication and social presence constituents of the MIM, indirect evidence was found that epistemic agency was co-developed since, according to the survey, participants were allowed to author themselves and their knowledge practices. However, they assumed limited responsibility for the advancement of their knowledge, which is explained by their previous experience with a more traditional pedagogical setting characterized by hierarchical workflow and one-directional information processing, which is still predominantly used in teacher training mentoring scenarios.

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PATRICK SINS AND JERRY ANDRIESSEN

13. WORKING WITHIN KNOWLEDGE COMMUNITIES AS A CONTEXT FOR DEVELOPING KNOWLEDGE PRACTICES

INTRODUCTION

Rapid changes in the current knowledge society present new challenges to human competence. Productive participation in knowledge-intensive work requires that individuals, their professional communities, and their organizations develop new competencies, advance their knowledge and their understanding as well as produce innovations. This is reflected in developments in professional communities wherein work is increasingly focused on deliberate advancement of knowledge rather than on the mere production of material artefacts (Bereiter, 2002). In parallel with these changes in society, conceptions about learning, knowledge practices, and social organization of learning have to be transformed to facilitate corresponding competencies. Epistemological issues related to learning and knowledge advancement are becoming increasingly important. In order to conceptualize and understand the nature of work and activity in current knowledge society, one has to comprehend the various types of knowledge that intersect within complex and heterogeneous networks that consist of humans and various artefacts (Engeström, 1999; Latour, 1996). Consequently, this necessitates an epistemological shifts within the field of education who are interested in adapting the educational system to cope with these emerging challenges.

Educational institutions that make an attempt at addressing these structurally different knowledge practices in their pedagogical approach are challenged to redesign (aspects of) their curriculum as well as to advance and support the practices and professionalism of their educators. This means that they are not only challenged to learn to go beyond their individual efforts and to collaborate within communities for the advancement of their knowledge practices but, moreover, their role is changed from one of delivering knowledge or designing pre-formulated tasks to a more open role involving providing process support for groups of students. However, although we are in a period of change, educational practice still has many characteristics of the transmission scenario (Andriessen & Sandberg, 1999). This scenario, which corresponds to the premises of the acquisition metaphor of learning (Sfard, 1998) – and that characterizes most formal education – centres on the acquisition of declarative knowledge and a limited number of critical skills by a system of lectures, textbooks, and testing. Therefore, to cope with the cognitive, social, and motivational challenges of the emerging knowledge-based society, tools

A. Moen, A. I. Mørch, S. Paavola (Eds.), Collaborative Knowledge Creation: Practices, Tools, Concepts, 233–248.

and methods are needed to improve the quality of learning and to transform the knowledge practices of educators accordingly.

Based on the works of Engeström (1987), Schatzki (2002) and Reckwitz (2002), we define a practice as follows: *a social-historically created and shared behavioural pattern consisting of an interconnected and inseparable array of recurrent activities, conventions, rules and norms that play a part in ongoing knowledge-mediated work.* According to this conceptualization, knowledge practices can be characterized by their social nature, which means that they are shaped by and evolve within a knowledge community, ultimately becoming part of its identity. In addition, the concept of knowledge practice entails stability as well as change. Stability is reflected as routines, procedures, conventions, underlying beliefs and values, epistemological conceptualizations and the set of available tools. At the same time, practices are open to change in that each activity based on this practice is adapted in response to changing contexts and particular circumstances. These transformations lead to historically new types of practices based on collaborative, tool-mediated knowledge production that takes place as long-term, sustained processes. These transformations ultimately lead to a reconceptualization of the object and motive of the community's knowledge practices to embrace a more diverse horizon of possibilities than in the previous practice.

However, practices are difficult to change, since they involve fundamental changes in views, beliefs, ideas and ways of working with knowledge that fulfil a certain need that is relevant for a particular professional community's knowledge work. In addition, changing existing practices would imply a negative evaluation of previous socially-grounded practices, but also because such transformation involves a period of disorientation while old practices are gradually unlearned and new practices are gradually developed (Eraut, 2004). During this period practitioners feel like novices, but without having the excuses or discounts on performance normally assigned to novices. The pain of transformation lies in the loss of control over one's practice when one's tacit knowledge ceases to provide the necessary support. In addition, Little (1990) reports that teachers, for instance, view transforming practices as involving high transactional costs to participatory work in time. According to Argyris and Schön (1978) the central problem for most professionals is that they are intellectually and emotionally committed to espoused theories which describe the world as they would like it to be, but which do not necessarily accurately describe their own activities and constrain possibilities for transforming their practices. Moreover, practices are similar to physical infrastructures in the sense that, when everything is working well, one does not pay attention to them (cf. Koschmann, Kuutti & Hickman, 1998). Consequently, educators rely on them even they are not fully aware of what constitutes them. According to these authors, these problems can only be solved when professionals step outside their taken-for-granted world and espouse theories to actively search for genuine feedback, which challenge the outcomes of their activities.

However, if we are to theorize about the significance of practice transformations, we must demonstrate how knowledge communities and professionals achieve these effects. Unfortunately, analyses of practice transformations, their antecedents and the ways they are reflected in and transferred to actualization in new practices have yet barely been the focus of empirical study. The goal of this chapter, therefore, is to report on a case study in the field of a school-university partnership at a secondary school. The main research question addressed in this chapter is: *what are the antecedents for practice transformations to occur within the context of collaborative knowledge-mediated work?*

CONCEPTUALIZING THE ANTECEDENTS OF PRACTICE TRANSFORMATION IN KNOWLEDGE COMMUNITIES

When people start to collaborate, a space is generated that provides conditions for collisions between perspectives, interests, practices, norms and traditions to occur. Consequently, collaboration involves the interweaving of cognitive-epistemic with socio-relational and affective aspects, which may generate conflicts, breakdowns or tensions (Sins & Karlgren, 2009). While tension can disable learning, several prominent perspectives on collaborative learning have maintained that tensions involve more than a simple disruption of ongoing collaboration; they comprise a vital precursor to learning and development to transform existing practices (Barab, Barnett & Squire, 2002; Dewey, 1966; Engeström, 1987; 1999; Schön, 1983).

Bakhtin (1981) introduced the concept of multivoicedness, referring to multiple perspectives, interests and traditions, which can be a source of tension as voices bring their own diverse histories, rules and conventions into the collaboration (Engeström, 2007). A tension occurs when meticulous, ongoing collaboration is interrupted by a collapse of shared intelligibility (Guignon, 1983) – for instance, when people press for conflicting answers about something that calls for resolution in the context of limited resources and differences in the exercise of power and authority. Based on the works of De Dreu and Van de Vliert (1997) and Kuutti (1996) tensions are conceptualized as *collectively explicated and acknowledged manifestations of a misfit within and between actor, tools and/ or objects, between different activities or between different developmental phases of a singly activity.* An example of a tension as described by Yamagata-Lynch and Haudenschild (2009) is that teachers articulated that their motivation and goals for participating in professional development were not in alignment with their school district and universities that designed and facilitated professional development activities. Often, tensions are not about the issue at hand but rather about what it represents. This means that misalignment articulated by teachers can be found as rooted in the conflicting value systems of individual teachers, school districts and universities regarding the allocation of resources on professional development activities.

Many scholars in psychology and organizational behaviour have explored the positive functions of tensions in collaboration (e.g., Amason, 1996; George & Jones, 2005; Jehn & Bendersky, 2003; Pondy, 1992; Prins, 2005; Tjosvold, 1998; Van de Vliert & De Dreu, 1994). Tension has been linked to learning, to higher levels of creativity and innovation, to improved quality of group decision-making and to increased overall performance. Socio-cognitive conflict theory (Doise & Mugny, 1984), cognitive dissonance theory (Festinger, 1957), the theory of cooperation and competition (Deutsch, 1973; Tjosvold, 2007) and cultural-historical activity theory (Engeström, 1987; 1999) propose that some form of tension renders elements of current knowledge practices problematic. Drawing upon the seminal work of Heidegger (1962), Dewey (1966) and Leont'ev (1981), tensions are viewed as a means for revealing the nature of our understanding and are conceptualized as the antecedents of opportunities for creative efforts in collaboration and can, as such, be conceptualized as the driving forces behind practice transformations (cf. Koschmann, Kuutti & Hickman, 1998). Perkins (2003) employs the metaphor of 'creative destructions' to describe how the displacement of old understanding and knowledge by new ideas and practices is the natural response to creative conflicts or tensions.

According to this perspective, tensions in collaboration are evidenced through resistance that is experienced by the members of a group. The underlying mechanism that explains how tensions in collaboration relate to learning and development is based on the premise that awareness of ignorance motivates learning (Nevis, DiBella & Gould, 1995). It is expected that this event precipitates a denouement in which the root causes of problems in the current situation are brought to the surface. This means that, in order to overcome tension, members in a group have to critically analyse and reflect on their collaborative activities and question and deviate from established norms and practices. This awareness of shortcomings and subsequent search for solutions to overcome resistance may lead to creative externalization or new ways of doing (Giddens, 1984). These new ways of doing can consequently become materialized as artefacts that serve to mediate or strategize the ongoing collaboration. For instance, rules and procedures can be formulated that allow coordination and fine-tuning of ongoing or future collaboration. Engeström (1999) maintains that in some cases this escalates into collaborative envisioning and deliberate collective effort toward changing practices. This suggests that tensions are not only an opportunity to improve, they are also of crucial importance to coordinate this improvement.

According to this line of reasoning, practice change occurs when a tension triggers an aggravating *awareness* of problematic aspects of existing practices that enables members in a group to consequently adapt their practices to arrive at a new, shared understanding. Thus, the argument put forward is that tensions serve an extremely important cognitive function, revealing to learners the nature of their practice and equipment, making them present-to-hand to them (Winograd & Flores, 1986). However, Nelson (2002) argued that the extent to which tensions can either enable practice changes or can actually disable it depends on whether they are acknowledged and *identified* by collaborating professionals. This means that tensions or contradictions in collaboration may not be easily identifiable or they may not be easily recognized, visible, obvious or even openly negotiated by those experiencing them (Capper & Williams, 2004). Capper and Williams conceive these invisible or tacit tensions, which include shared cultural conventions, as the most problematic in paths towards learning and development. But this argument does not exclude the possibility that even if tensions are identified, this does not necessarily lead to an improvement of practices.

According to Wickman & Östman (2002) this process rests on professionals subsequently noticing and filling gaps by construing new differences and similarities in relation to what is immediately intelligible to them. To resolve tensions, learners need to *frame* and to reflect on current conventions, rules, procedures, norms, perspectives and goals to arrive at new shared understanding and collaborative knowledge practices. Suchman (2007) has even argued that when professionals transpose conventions without the occurrence of tension this does not lead to practice transformation. On the other hand, when there is an implicit consensus about existing conventions, and utilization according to these conventions does not cause tension, then professionals may arrive at the stage of collective utilization without substantial reflection on their activity. If this is the case, professionals merely reproduce their regular activity with new meditational means, without any of the intended transformations.

The challenge in this argument is that professionals involved in collaborative knowledge work, and who aim at improving their existing practices, need not only to *create awareness* and to *identify* particular tensions but also to recognize that collective *framing* of these tensions is required in such a way that reflection occurs and opportunities towards practice transformations are *generated.* But to what extent are these processes empirically substantiated as antecedents of indications of practice transformations in knowledge-mediated group work?

To address this question, we will present a case study that focuses on describing tensions that occurred between group members in an intensive and long-lasting university-school partnership, and how their resolution pointed to instances of practice transformations.

PEDAGOGICAL SETTING

The case study took place at UniC, a secondary school in Utrecht in The Netherlands. The university-school partnership involved a 2-year collaboration (between 2006 and 2008) to redesign a learning module to enhance secondary level students' learning, based on knowledge creation principles (Paavola & Hakkarainen, 2005). One central feature of the knowledge creation approach taken up in the design was the concept of *mediation,* which means that students' activities were directed towards the collaborative creation and advancement of shared knowledge artefacts (e.g., documentaries, research reports or instructional material) mediated by specific supporting technological and conceptual tools.

At UniC, students are coached for the national school exam, complementing the focus on knowledge acquisition by stressing development of competencies, skills and personal development. Students are enabled to develop their own talents and interests in a course module in which they plan and perform projects within or outside of the school context. This means that every week in the curriculum a half day is reserved for these projects for periods each lasting eight weeks. The school supports the students and offers ways of carrying out their projects. Within this pedagogical context, teachers' coaching practices traditionally focus on the development of courses and assignments providing guidance to students' self-directed learning process.

UniC expressed the aspiration to challenge their students toward more meaningful learning. In addition, the teachers' expressed that their role during the aforementioned projects was unclear and that they needed more scaffolds to structure their coaching. Therefore, a multi-disciplinary team consisting of 4 educational researchers, 4 teachers, the dean, a process coordinator and a pedagogical expert was set up to flesh out the design, based on knowledge creation principles which matched UniC's general pedagogical approach and objectives. The collaborative design, implementation and testing of the new course module implied that high demands were placed on the coaching practices of the teachers which provided a platform for tensions to arise. For instance, they had to: (a) comprehend the theoretical principles behind the knowledge creation metaphor, (b) apply these principles in their practice, and (c) reflect on their role as a teacher and transform their practices accordingly to scaffold students' knowledge creation processes. To accomplish this aim, the multi-disciplinary team at UniC had to create conditions for reflecting on and advancing their practices in the face of the interchange between the different possibly conflicting voices and modes of knowledge.

AN EMPIRICAL ANALYSIS OF PRACTICE TRANSFORMATION AT UNIC

Multiple, intertwined methodological approaches and various approaches to data collection and analysis were combined to elaborate on the dynamics of incremental changes which reflect practice transformations resulting from patterns of tension resolution. We performed ethnographic methods with participatory observation, developmental intervention approaches, interviews and event sampling to follow processes towards new practices. Our analyses took tensions in activities as a point of departure. We looked for episodes in the material that expressed problems and materialized as developmental tensions.

Subsequently, we investigated discursive activities between project team members (micro level), elaborated on episodes of tension resolutions over time (meso-level) and examined how patterns of tension resolution related to transformations of practices at the level of trajectories (macro-level). For framing the analysis we developed the following approach:

1. Description of the nature of tensions in existing practices that are articulated;
2. Exploration of resolutions to these tensions, characterization of tension-resolutions and analysis of how these contribute to transformation towards new practice over time;
3. Examination of the formalization of the practice transformations.

To assess the knowledge practices of the actors involved in the multidisciplinary design team at UniC, we combined data collected from different instruments, namely:

- Material artefacts, such as reports, concept maps, and written comments;
- Pre- and post questionnaires administered to both students and teachers;
- Semi-structured interviews with students and teachers;

- Transcribed recordings and minutes of the meetings of the design team;
- Transcribed recordings of meetings between students and their teacher.

These instruments were mainly designed to capture critical events during the meetings of the project partners and to discern how these events are echoed in indications of practice transformations. Critical events were conceptualized as articulations of tensions during project team meetings and were afterwards checked with the team members.

Our first aim was to describe how the project team overcame tensions, creating conditions that foster transformations of the knowledge practices of the teachers involved. To address this issue, we found that most tensions were observable on the boundary of the intersecting voices of researchers on the one hand and that of the dean and teachers on the other, showing how team members balanced institutionalized or traditional with newly-developed practices. One particular source for tensions involved the specific organization of teachers' coaching to be more in line with the new pedagogical approach and at the same time foster students' knowledge creation processes. The following excerpt exemplifies this tension during an interview with one participating teachers:

1	**Teacher3**	I see that an increasing number of student groups do not have a clear view of what they are doing, that is what I am afraid of, unfortunately	Highlighting the tension
2	**Researcher1**	How do you coach these students then?	
3	**Teacher3**	Well, you cannot just leave them, this would lead to chaos. […] You can divide tasks in the group and think of who is going to do what, but then I would be too directive and I am not sure whether that should be our intention, so therefore I give them more freedom […]	Identifying the issue
4	**Researcher1**	[…] Well you mean that you are still in search of what is expected of you as a teacher.	Framing
5	**Researcher1**	What do you need in your coaching?	Generating solutions
6	**Teacher3**	First I need to know more about knowledge creation, what the idea and what the pillars are, so I can eventually adapt my coaching to that […] normally I am very clear in my teaching, but in this pilot it seems that you have to discover what the best ways of coaching are	

Interview Teacher 3; December 2006

In passage 1, Teacher 3 expresses his concern with respect to his observation that students have not been successful in organizing and structuring their work. When prompted for his ways of coping with this tension in his coaching, he states he would like to be more directive, saying 'you can divide tasks in the group' (passage 3). At this point, he identifies a conflicting perspective with what he interprets as the coaching practice which would comply with principles of knowledge creation 'but then I would be too directive and I am not sure whether that should be our intention, so therefore I give them more freedom' (passage 3). Eventually, for him to overcome this dilemma, he proposes that more guidelines for coaching students' knowledge creation processes have to be generated. In sum, this episode points to a pattern where *highlighting* a tension contributes to the *identification* of an issue between what can be interpreted as top-down instruction at one hand and social distancing at the other. Teacher 3 was reluctant to interfere with students' activities too much, since this would be in conflict with his emergent perspective about what is important when fostering students' knowledge construction. In passage 4, Researcher 1 frames this perspective by stating that he is 'still in search of what is expected' of him as a teacher (i.e. *framing*). Eventually, Teacher 3 *generates* some ideas for adapting his knowledge practices as indicated in passage 6.

This epistemic stance was echoed in teachers' coaching practices involving teachers' facilitating students' knowledge creation processes at a distance instead of being an active part of it. More specifically, although teachers enacted a different role from what they formerly adopted, they placed themselves outside the collaboration process of their students, which was found in their interactions with them:

1	**Teacher3**	And where does this go? Is it going to be one product that is going to be part of your documentary? Or are they going to become three independent products? How do I have to see this? Can you tell something about this? Or do you not know how you want to see this?
2	**Student1**	Well it has something to do with the film, but it was really his own idea
3	**Teacher3**	Is it more like, a book of reference after the film? Next to the documentary? You were talking about a story, that it would become a story? Or?
4	**Student2**	Well … Yes. In principle I made the whole story and then I had a piece of the film that was placed in the future. And then I create an idea around this, you know, that is what I am going to show in those films […]
5	**Teacher3**	Okay, you are going to show them in the film? Your ideas of the future?

Protocol meeting T3 with student group; December 2006

This episode shows Teacher 3's enactment of mainly posing explanatory questions about the nature and status of the student group's activities without enquiring about the exact nature of content of their work. In some cases, however, this led to the problem of some students reporting that they sometimes experienced their teachers' support as being disruptive in the context of their activities:

Researcher3	What do you think of your teachers' coaching?	
Student1	Well, sometimes teachers ask us just too often what we are doing and what our end product will be; what we want to achieve. But in most cases, we had explained that seven times already and they still want us to explain it even further; while we even do not yet know how far we can go; that is quite annoying	Highlighting the tension

Interview Student group 4; December 2006

This episode shows that, although teachers had adopted more liberate coaching approach, this caused tension with students' experiences of coaching. Furthermore, teachers acknowledged that their coaching contributed to exasperating students in their knowledge creation and more structure was needed. This was put forward during a subsequent plenary meeting of the design group:

1	**Teacher3**	[…] Well, it seems our students do not have a clear idea of what they have to do	Highlighting the tension
2	**Designer**	Students have to know what the assignment entails […]	
3	**Ped. Expert**	[…] So I would suggest that the teachers can focus on helping students in creating these structures. […]	Identifying the issue
4	**Researcher3**	Students could concretize their ideas in a plan	
5	**Teacher2**	So I would like to coach them to make it clearer about what the object is and its requirements.	
6	**Teacher2**	So far, we have maybe been too reserved.	
7	**Ped. Expert**	That is very important, and then those group members will follow their own work structure. […]	Framing
8	**Reseacher2**	Still, it is not a bad thing that it is going like this, if they first muddle a little, […]	
9	**Ped. Expert**	But you shouldn't let that continue for too long	
10	**Teacher1**	But, what you see now. That we should give a little more structure	
11	**Teacher2**	We can ask students to use the so-called Tabasco plan, which they are already using to construct. In this plan they have to specify the activities they are going to perform, what the end objectives are. This can serve as a tool for teachers to monitor students' progress without being too directive or strict […]	Generating solutions
12	**Process coordinator**	And you could revise this plan, which leaves it more open for students […]	
13	**Teacher2**	Apparently that is needed	
14	**Researcher3**	So, it is our observation that that is needed, yes.	
15	**Teacher2**	Well, that is clear by now. This shows that a good start is necessary. There has to be a concrete object and once that it is there, it will go well	

Protocol meeting project team; January 2007

In this episode Teacher 3 *highlights* the tension in passage 1: '... it seems that our students do not have a clear idea of what they have to do' (passage 1). This is followed by *identifying* the issue between what can be interpreted as social distancing at one extreme (see passage 6) and top-down instruction at the other (see passage 10) which is rooted in the teachers' concern over warranting their students' meaningful learning (i.e. *framing*). The suggestion that is put forward to overcome this tension is to synthesize both perspectives in a concrete manner, '... We can ask students to use the so-called Tabasco plan which they are already using to construct' (passage 11). This is accepted and taken up by the others '... apparently that is needed' (passage 13) (i.e. *generating* solutions).

Another issue is related to Teacher 3's concern regarding the lack of guidelines for coaching students' knowledge construction, and the contribution and roles of the members of the project team in the coaching practices:

1	**Teacher3**	Nevertheless, it is important get more assistance during work sessions because now there is only the three of us ... that is my first concern	Highlighting the tension
2	**Designer**	It should be sorted then, we need teachers for this class […]	
3	**Teacher1**	Sometimes you [Researchers] are a little blunt It is not criticism but I noticed that you have you own agenda You don't really help us coach, we just have to take care of it. In my opinion that is not really being an actor!	
4	**Researcher1**	Well, the idea was that we didn't want to participate as a teacher because we don't have that expertise, though we are here to provide you with some advice and answer your questions, if you have any	Identifying the issue
5	**Teacher1**	[…] I am teaching the knowledge creation project on my own which is not an ideal situation, I just want you to think with me. Clearly we don't expect you to teach […]	
7	**Researcher1**	Well, I believe that is a good thing to hear, I am glad that this came up	
8	**Ped.Expert**	The researchers are used to staying in the background to be able to observe the process as objectively as possible	Framing
9	**Teacher2**	There is a big culture difference because we are used to everyone being involved You are thinking as observers	
10	**Process Coordinator**	It is a type of participation when you are observing […]	
11	**Teacher2**	You could divide one group into two so that T1 has to coach his own groups but that T4 and T1 meet each other during class to discuss any problems or to ask each other for advice	Generating solutions
12	**Designer**	You can then also ask researchers for feedback during coaching […]	
13	**Resarcher1**	Yes, that would be perfect [everybody agrees]	

Protocol meeting co-project team; January 2007

This episode shows the *highlighting*, *identification* and *framing* of an issue that exists between the work traditions of researchers on the one hand and teachers on the other. The tension that was articulated '... it is important get more assistance during work sessions because now there is only the three of us' (passage 1), opened up for explicating the underlying conflict between the perspectives of researchers and teachers regarding their role during the coaching of students' knowledge creation processes. Utterances such as '... You don't really help us coach, we just have to take care of it. In my opinion that is not really being an actor!' (passage 3) versus 'Well, the idea was that we didn't want to participate as a teacher' (passage 4) illustrate this tension. Subsequently this resulted in a framing of these conflicting perspectives from the view of the traditional work practices of both groups to create common understanding '... There is a big culture difference because we are used to everyone being involved. You are thinking as observers' (passage 9). Eventually, partners *generated* suggestions to overcome this tension by a division of labour '... You could divide one group into two […] you can then also ask researchers for feedback during coaching' (passage 11).

In sum, we found a pattern in the ways tensions were resolved by project team members, consisting of moves in the interaction, starting from *creating awareness*, *identifying* an issue, *framing* it collectively, eventually leading to the *generation* of solutions. To examine whether this pattern could be identified in the interactions between team members during project meetings (i.e. meso-level), we scored the meeting in December 2006 employing the programme Transana 2.42 (Wisconsin Centre for Educational Research; http://www.transana.org). Figure 13.1 shows part of a keyword map generated by Transana 2.42, where the distribution of assigned codes for 8 minutes of discourse is represented. Figure 13.1 shows that the processes *create awareness, identify, frame* and *generate* (the first four rows) tend to follow in sequence.

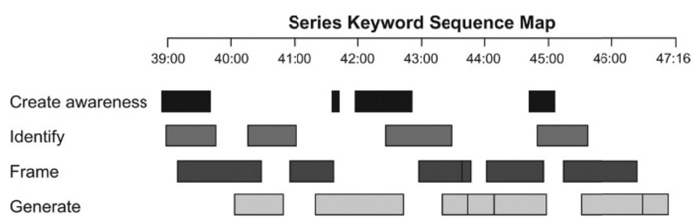

Figure 13.1. The keyword mapping feature in Transana showing the distribution of selected codes along a time line. Greyscale values denote the events (slices in time) to which the codes were assigned for 8 minutes of discourse.

We found that the abovementioned developmental tensions set the stage for collaborative analysis and for the creation of a shared understanding to overcome them and generate suggestions for changing knowledge practices on the macro-level accordingly. For instance, teachers' coaching transformed towards an increasing emphasis on the collective construction of planning together with students. This would help students to organize their work and offered teachers a tool that enabled them to monitor students' progress during their knowledge creation projects:

> **Phase 1 in coaching knowledge creation**
> Do students have a clear plan?
> What are they eventually going to show, what is their object?
> The teacher has a specific role in this process
> 'Go' or 'no go' decision
> Slide taken from presentation of Teacher3; March 2007

In this artefact, i.e. presentation provided to other teachers at UniC, Teacher 3 shows that that the significance of 'planning' is echoed in teachers' coaching practices. This theme can be traced from the tension that team members identified and attempted to overcome earlier. Moreover, Teacher 3 took up this idea and implemented a 'go-no go' decision in his practice. Then students had to negotiate their plan with their teacher before they were allowed to continue with their projects:

Researcher3	How do you see your role as a teacher now, what is most important?
Teacher3	Well. First that students chose a subject and that they construct a plan. And the task of the teacher is to perform a reality check and argue whether the students' plan is a good one or not, to give a 'go' or 'no go' decision at the start. There is where the teacher plays an essential role and this plan gives a good tool for me to observe what is happening and to ensure that students keep in a 'flow' towards the end

Interview Student group 4; December 2006

In this excerpt, Teacher 3 reports that he had adapted his more liberal coaching style to such an extent that he now asks his students to construct a plan and that it is the teacher's task to decide whether students can continue in pursuing their knowledge construction according to this plan or that they have to construct a more realistic or challenging plan.

Tension resolution of conflicting perspectives about division of labour between members of the project team resulted in creation of a joint venture agreement:

For Utrecht University this agreement involves:
To perform research at UniC in collaboration with teachers and students concerning the concept of knowledge creation and support thereof
To realize a long-term relationship between research and educational practice, in which knowledge, insights and experiences are exchanged with the aim of learning and capitalizing from each other

For UniC this agreement involves:
To obtain more insight and tools to experiment with possible solutions for the challenges and issues which structurally occur in educational practice
To realize a long-term relationship between research and educational practice, in which knowledge, insights and experiences are exchanged with the aim of learning and capitalizing from each other

Joint venture agreement, first version; April 2007

DISCUSSION

This chapter focused on tensions between project members in a university-school partnership, and how their resolution points to practice transformations. The findings illustrate that interaction between different knowledge trajectories occurred on both the individual and collective platform of the project team and how participants stabilized out of flux by changing their practices accordingly. During meetings, practical pedagogical enacted knowledge of teachers intersected with social practices of the educational researchers. At this level, tensions surfaced on the nexus of perspectives, agendas and interpretations of the actors involved in the collaborative design in the university-school partnership. The attempts undertaken to overcome the identified tensions involved creation of artefacts (e.g. the joint venture agreement) that serve to objectify and afford this transformation.

Tacit knowledge (represented as the network of implicit epistemological beliefs, attitudes and knowledge) was explicated during group meetings and ideas expressed were often taken up by the group and integrated within existent practices, or became the driving force behind the development of relatively new knowledge practices. For instance, the tension between top-down instruction versus social distancing and differentiation of coaching styles was resolved by a collective envisioning and fleshing out of more directive coaching practices. More specifically, more emphasis was placed on employing students' planning as tools to monitor and to scaffold students' knowledge creation.

Based on the findings reported in this chapter, we have derived a generic pattern of managing or resolving tension, namely: highlighting, identifying, framing and generating solutions:

1. *Highlighting the tension*: Often, tensions are not about the issue at hand (e.g., scheduling a meeting) but rather about what it represents, such as the experience of disrespect or the illegitimate exercise of authority. A tension could only arise as the consequence of one of the professionals in the knowledge construction work to describe a particular problem at hand;
2. *Identifying the issue*: as a result of professionals knowing what the issue at hand is, the contradictions in perspectives, knowledge, attitudes or affects come to the fore explicating the problematic features of the practices under scrutiny. These tensions are explicated in the voices of the several professionals in the collaborative knowledge construction work;
3. *Framing*: subsequently, the tension is framed employing the self-created language, norms and rules of the knowledge community. This framing is necessary for creating a shared understanding of the tension and for constructing a representation of the forces acting in preserving and causing the problematic practices at hand. This will eventually enable professionals to adapt their practices to be able to overcome the tension;
4. *Generating solutions*: Finally, professionals transform their own or shared practices, construct new tools and implement them in the ongoing knowledge construction work.

Based on socio-historical perspectives on learning and development, we have appropriated the notion of developmental tensions as a driving force of change and development. Although we do not claim that developmental tensions are the sole impetus of transformations of work practices, the investigation of tensions and their resolution helps to identify the dynamic forces of change and comprise an important constituent and starting point for investigating such processes (Barab et al., 2002; Engeström, 1987; Koschmann, Kuutti & Hickman, 1998; Murphy & Rodriguez-Manzanares, 2008). For the research reported here, the identification of these tensions provides a starting point for investigating and explaining practice transformations in knowledge creation contexts. In future research this generic pattern for tension resolution will be tested in other knowledge-mediated collaborative settings.

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ANNE MOEN AND STURLE NES

14. CONSOLIDATING WORK DESCRIPTIONS: CREATING SHARED KNOWLEDGE OBJECTS

INTRODUCTION

As a professional practice, health care is an arena where the increasingly complex, knowledge-laden practices offer interesting opportunities to study knowledge creation processes. Contemporary care and treatment takes place as highly complex, intertwining and specialized activities where professionals combine generalized knowledge, local interests and patient needs. Development in health care and public scrutiny of offered services has led to evolving knowledge practice emphasizing best quality and safety for the individual (IOM, 2000, 2004). This is a shift posing numerous challenges to traditional, often habitual and rule-governed actions. It has led to elaborations of the knowledge resources that inform practice, and pinpoint practitioners' experiential knowledge and preference to consult informal and interactive resources (Estabrooks, et al., 2005; Spenceley, O'Leary, Chizawsky, Ross & Estabrooks, 2008). Addressing such challenges has not been straightforward, requiring investigation of what constitutes good evidence or what counts as knowledge and best available evidence to solve particular problems.

New expectations and requirements to balance accumulated clinical experience, evidence from patients and available research to ensure quality care (Kitson, 2002) coincide with efforts to establish *evidence-based practice*. Evidence-based practice (EBP) is understood as 'the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients' (Sackett, Rosenberg, Muir Gray, Haynes & Richardson, 1996, p. 71). EBP for nurses, in particular, rests in the incorporation of evidence from research, clinical expertise, and patient preferences to care for the individual patient (DiCenso & Cullum, 1998). In reality, this is an initiative to transform practice by integrating and accumulating individual, clinical expertise, i.e., proficiency, judgment and experience, with the best available evidence from systematic research not restricted to randomized clinical trial and meta-analysis. Efforts to achieve EBP can be seen as ongoing knowledge creation processes for practice transformation, and ties into epistemification and a knowledge society move.

One significant initiative in ongoing efforts into transforming to evidence-based practice is provision of recommendations, guidelines or work descriptions (procedures) accessible as knowledge resources at the point of care (IOM, 2001; Sosial- og helsedirektoratet, 2005). Procedures have a long history in health care, serving as written recommendations explaining how to perform certain work

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according to set quality and safety expectations. Local experts, most often senior physicians with in-depth knowledge and accumulated experience in the area the work description applies to, wrote the hospital's in-house procedures. Based on their choices and discretion, the procedures might adhere to external standards and national recommendations for best practice. The procedures were classified according to institution-wide, department or unit specific applicability. Over time practice evolves, making the in-house versions of a procedure more or less updated and accurate. Therefore local amendments and many versions of each procedure are quite common (Størseth & Moen, 2007).

As an initiative to develop work descriptions applicable beyond the specific institution, PPS (Practical Procedures for the nursing Service) is a pool of standardized nursing procedures available as updated, evidence-based knowledge to large number of practitioners in community health, specialized hospital care and as an introduction to clinical nursing activities. In PPS a team of nationally recruited experts writes the procedures. The structure is (a) step-by-step text descriptions with illustrations, animations, photos or video to complement the written explanations; (b) general information about the procedure; and (c) topic-sensitive access to the knowledge base and comprehensive learning module with further explanations related to the procedure and domain that the procedure supports. This blends knowledge and accumulated experience, national recommendations for best practice and research-based knowledge as new evidence supporting their descriptions. Each standardized procedure with its step-by-step description, displays by default the following information: 'description of how to', 'devices/equipment' and 'observations'. The PPS is now a commercially available electronic repository, currently containing around 300 standardized, clinical procedures performed by nurses (Akribe, 2011).

The approach to create a shared knowledge resource like the one we study in this case is a new type of initiative to provide an updated knowledge resource and accurate, best-practice work descriptions. This ties into discussions of what counts as knowledge and how knowledge resources are created and evolve in the interplay of mobilized knowledge and experiences, which is crucial for our investigation of professionals' practices use of knowledge resources and creation of knowledge objects (KP-Lab, 2006). Therefore we set up a longitudinal case study to explore knowledge creation processes for change and transformations in a large university hospital. One of our foci was to explore consolidation of local, in-house procedures and standardized procedures in PPS to create a consolidated repository of work descriptions for patient care. In this chapter we use examples from negotiations to consolidate work descriptions to illustrate the creation of knowledge objects that may transform evolving activity and mediate learning in the workplace.

FRAMING THE STUDY

Healthcare practices and nurses' work are examples of practices developing as more specialized, increasingly complex and knowledge dependent work. Compared to traditional images of nursing where rules, routines or embodied skills were most important, contemporary nursing can be seen as a knowledge-intense practice that is more dynamic, creative, and constructive (Miettinen & Virkkunen, 2005; Sandelowski, 1999). Attending to patients' care needs should be approached as solving open, ill-defined problems, requiring context-dependent combinations of knowledge, accumulated practical experiences and personal experiences from comparable situations to handle the specifics in a situation.

From this perspective, healthcare and nursing increasingly display characteristics comparable to the complexities previously described in studies of science and networked expertise of a knowledge society (e.g., Hakkarainen, Palonen, Paavola & Lehtinen, 2004; Knorr Cetina, 2001). New knowledge and experience add to existing, collective expertise, accumulated experiences and practical skills, and contribute to evolving artefacts and knowledge infrastructures (Keating & Cambrosio, 2003). Work description is one such available resource to keep up with increasing demands for knowledge, and to contribute to a practice where the same type of work is performed without too much variation.

Zooming in on the participants' negotiations to consolidate an in-house pool of procedures and PPS-repository offers the chance to understand object-oriented inquiry in professional practices. A consolidated work description is a new knowledge object and, as such, is question-generating and open to change (Knorr Cetina, 2001). There is an inherent lack of completeness, meaning that work descriptions evolve and change as they are used in professional work. Therefore, a work description differs in important ways from commodities and specific, embodied rules because their content is used and adapted according to situational interpretation of the particular situation (Nes & Moen, 2010). The processes of negotiation to create knowledge objects as shared artefacts, i.e. consolidated work descriptions, provide a window to explore the resources that are mobilized. The professionals we observe collaborate and interact in a hybrid, shared space constituted by their participation, available versions of work descriptions in digital and paper form, and other knowledge resources they identify and introduce to explicate experiences and different understandings.

The Case

Our longitudinal, exploratory case study focuses on processes of knowledge creation for practice tranformation. The empirical data has been collected from a large university hospital in transition to a new building. The new building was designed to support their vision for work processes labelled as patient-centric, evidence-based treatment trajectories. Such processes rely on ICT-enabled resources and other advanced technological tools in addition to staff mobility and new division of labour. A comprehensive knowledge management system providing resources at the point of use is therefore a prerequisite. One component in this comprehensive knowledge management system is work descriptions for nursing, consolidated from (1) local, in-house nursing procedures, and (2) standardized work descriptions from the PPS repository. The outcomes of the consolidation processes materialize as a work description based on PPS, with a *'red space'* added to each procedure (Ahus, 2006; Nes & Moen, 2010; Størseth, 2006). They will use the '*red space'* as a dedicated area to communicate the status of each work description as part of the hospital's recommendations and guidelines.

At the hospital, the joint efforts to review and consolidate work descriptions are seen as a necessary process before making the consolidated work descriptions available as shared knowledge objects, institution wide. The process to consolidate the two pools of work description is organized as follows: the initial review and negotiations take place in working groups. Members of a working group were recruited based on their expertise in the clinical area the work descriptions dealt with. Two to four expert nurses from the clinical area where the procedure is most frequently performed, and one or two group leaders, review the hospital's existing pool of procedures and the PPS system's procedures. Depending on the number of procedures pertaining to the clinical area and differences between local practice, in-house procedures and PPS-version of the work description, the working group meets three to six times. Each meeting lasts approximately two hours. Their suggestions are summarized and forwarded for additional review in a reference group where representatives from all of the hospital's clinical departments are members. To conclude this process, the hospital's CEO approves their recommendation, and the consolidated work description is published in the knowledge management system.

Our data corpus is heterogeneous, and includes (a) collection of their artefacts and relevant documents; (b) stakeholder interviews, approximately 10 hours with 13 informants recruited among participants in the consolidation process and senior executives; and (c) participatory observation of working groups; recordings and observational notes from 23 meetings, approximately 23.5 hours video or audio, and observational notes from approximately 10 hours of meetings. For this paper we have selected empirical material from participatory observation of working group processes to elaborate professionals' interaction when consolidating work descriptions. In the example, differences surfaced and negotiations drove the interactions towards consensus about the text to be added in the *'red space'*.

EMPIRICAL MATERIAL – CONSOLIDATING WORK DESCRIPTIONS

As an illustration of negotiations in their knowledge creation processes we will share material from the consolidation of work descriptions related to 'thoracic drainage'. As preparations for their efforts to reach one version, the consolidated work description for 'thoracic drainage', several resources are mobilized. The sources include procedures from the existing pool of the institution's paper-based nursing procedures, specialized procedures from the units most often caring for these patients, the PPS version of the work description and other material such as guidelines and existing equipment. There would be several versions describing similar work processes, some had scribbled additions, and some were written more than 10 years ago, illustrating problems of maintenance and accuracy (Størseth & Moen, 2007). Working group members bring in other material they saw as support to elaborate their position and as contributions to the consolidation process.

Our observation of the negotiation processes in the working groups and reference group meetings were subject to interaction analysis (Jordan & Henderson, 1995). Going into the analysis at the micro-level, we are specifically interested in how working group members mobilize and use available resources, knowledge, experience and objects in their ongoing negotiations/interactions, and how their unfolding interactions materialize as new/modified knowledge objects. Their collaborative knowledge creation process is seen as achievements leading to consensus expressed in *'red space'*. The empirical example related to the specific procedure, thoracic drainage, describes relatively advanced and non-trivial work for health professionals. They have to take special care over how to set up and observe the equipment that connects the patient to the vacuum in the wall. To illustrate her points, Siw, who is recruited as a local expert from the unit most often exposed to patients requiring this treatment, had brought parts of this equipment along to the meeting to illustrate her explanations to the other group members.

As the selected sequence of excerpts starts, the working group has reviewed and discussed different versions of work descriptions, and exchanged some experiences. Their negotiations led them to suggest additions to the work description. They recommend adding specific explanations of 'how to do' the procedure, in particular focusing on the safe handling of the necessary equipment to assist in this type of work. The group leader starts before the other participants, Siw and Trude, elaborate the specifics about the equipment:

1. **Group leader:** ... with regard to equipment ... we'll add a link to the synopsis or the appendix you will work on [*addressing Siw*] that should be appropriate for all four procedures about drainage and vacuum manometer [in PPS], and for this procedure ...
2. **Trude:** ... you had the vacuum manometer as equipment, but then you do not need it there [as equipment] because it comes in ...
3. **Siw:** [i*nterrupts*] … I think that all equipment should be there [in the description], it is not always the case that the vacuum manometer is in the room already. We do not have enough of them to keep them in every room for example. And you shall check if you have got everything [required equipment] with you. They will find out during the procedures, I hope, that the vacuum manometer is missing [*laughs*]
4. **Group leader:** Drainage ... vacuum manometer – what is it really?
5. **Siw:** It is the part you connect to the wall [*for vacuum control*]
6. **Group leader:** Right, and it is not enough to have them placed all over.
7. **Siw:** Right
8. **Group leader:** I did not know that, but isn't it quite obvious ...
9. **Siw:** Yeah, well you find out when you are in the room, and connect the pieces, you see that you are missing some parts. So you get what it is ... But I think that when you are look up the procedures, and look at what equipment you need ...

Here they start summarizing how to proceed to create the *'red space'*, clarifying that this is also relevant to other work descriptions relating to other aspects of this treatment. They also negotiate division of labour (passage 1). To clarify further, they sort out where in the common structure to add their pieces (passage 2). Here different expectations for completeness of each description, mindful of institutional constrains like availability of this specific equipment at the bedside, are taken into account (passage 3). The group leader's question about what the specific equipment is adds further clarification, and helps explicate the non-trivial or non-obvious part of the work they are elaborating (passage 4–8).

Since *knowing what should be there is seen as a common, everyday problem* it is important for them to include this information in the *'red space',* and their specifications aims to prevent problems or avoid inefficiencies when setting up the equipment. They therefore put forward suggestions about adding practicalities to the shared knowledge object to complement the PPS version of the work description. As the interaction continues, they negotiate how much they should say, how detailed and if the addition is really necessary or if it is obvious that certain equipment is needed.

10. **Group leader:** ... then it is not said there [in PPS].
11. **Siw:** ... it is not said there, right ... [*pause*] and when you go to the room and it [vacuum manometer] is missing, you have to go and get it. That is not very efficient.
12. **Group leader:** Right, it is not efficient.
13. **Siw:** Then you must learn to remember the next time.
14. **Trude;** Make sure there is drainage, vacuum manometer and access to vacuum in every room.
15. **Group leader:** ... [*mumbling*] ... and hope every room has it too.
16. **Siw:** The new hospital should have this [refers to the new building].
17. **Trude:** Should have, sure, not sure they have more money though.
18. **Group leader:** Drainage, vacuum manometer, no, I think it is so local that it should be part of what you write ... so then it is just the connector ...
19. **Siw:** [*interrupts*] ... local with drainage, vacuum manometer? THAT is not local, it isn't ...
20. **Trude:** ... No no, but you understand it ... that you need the vacuum.
21. **Siw:** Yeah, of course you understand, of course, but when you are there as a new grad, new nurse and you have to think about everything. Then you may not remember it [the vacuum manometer].
22. **Trude:** Right.
23. **Siw:** If you put it in [add text] and have seen it once, then you remember the next time.
24. **Group leader:** OK, then we add drainage, vacuum manometer in the comment field, plus a link to the text you will write.

In this interaction, different views about how comprehensive the explanations in the work description ought to be drive their negotiation. They go into how elaborate or explicit the addition should be (passage 10–12) as they refer to the current problem of non-availability of this equipment in every room where needed (passage 14–17). This local constraint requires the nurses to learn and remember this specific point (passage 13 and 20), and, since they do not remember, it should be added as a reminder to the work description. As they sort out this aspect, another line of argument, about how far local practice and local constraints should direct their elaboration, is brought in by the group leader's question of the necessity to add too much to local specifics (passage 18). The local expert, Siw, strongly opposes the question (passage 19). As they continue, they come to a closure that the knowledge object they are about to create would be specifically important as a resource for new or less-experienced colleagues (passage 21), since they expect people to remember following exposure to this kind of work (passage 23). They close their elaborations with support for the detailed approach started by Siw, and summing up additions to the work description about this aspect (passage 24). Their interaction continues as they sort out other suggested additions.

25. **Siw:** Yeah, What is the next item you had?
26. **Group leader:** 'Assist when removing thoracic drainage.'
27. **Siw:** Yeah, but as we ... so I should only include what we have talked about now ... what I think ... it is this routine with chest X-ray two hours after the thoracic drain is put in.

Here they specify examinations that are necessary follow-ups related to the procedures for chest drainage and removal of thoracic drainage. This suggestion 'chest X-ray two hours after' refers to their local conventions (passage 27). Including this item adds to a work description and explicates aspects of what a nurse is expected to know and do related to the procedure: 'thoracic drainage'.

Then, as their interaction winds up, the group leader attempts to limit the PPS-based work description's '*red space'*. This constraint forces them to choose between a text immediately visible when opening the work description and a longer, hyperlinked appendix that is less visible.

28. **Group leader:** It is only 200 characters that we can include [in the immediately visible red space] so ... you have to write the additional text.
29. **Siw:** ... so include it in the appendix then. But it was kind of nice that it should be there [in the immediately visible space]
30. **Group leader:** Sure
31. **Siw:** Yeah, and then the reference group looks at this [appendix to be prepared] too.
32. **Group leader:** Yes, this [the appendix] should be approved by the reference group. I feel that we need a small review when this [the appendix] is written.
33. **Siw:** Yeah.
34. **Group leader:** Short meeting, circulation and commenting over the net.
35. **Siw:** Yeah.

When the Group leader points out that the number of characters in the *'red space'* is limited and that the additions have to be an additional text (passage 28), two things happen. First, they comment about the availability of the addition, stating a preference for the instant view (passage 29). Second, they explicate the process to add material to the PPS work description (passage 31–32), and for group members to agree on the text in the appendix (passage 32–34). This last move illustrates that the permitted room for expression adds to the processes of knowledge creation. The picture of their consolidated work description is shown in figure 14.1.

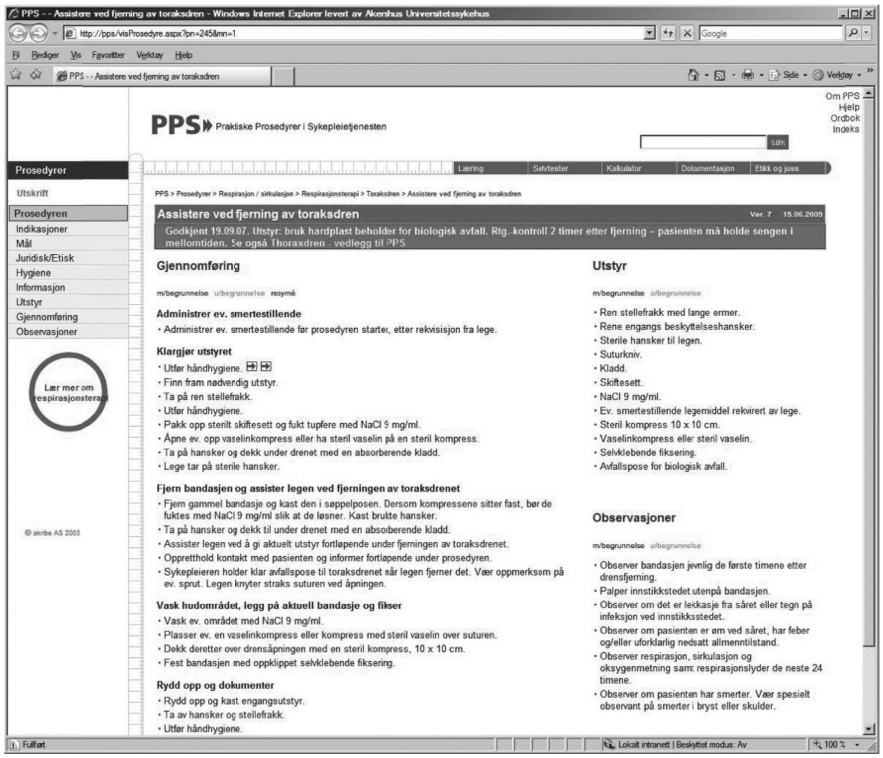

Figure 14.1. Consolidated work description.

The outcome of the specific interaction above, and the *'red space'* added to the work description illustrated by the darker grey field in the upper part of figure 14.1, exemplifies materialization of the new, modified knowledge object.

DISCUSSION

The empirical example of unfolding interaction above illustrates processes of working with different knowledge resources. These resources are mobilized as they negotiate and take a stand to consolidate their recommendation for each procedure, written as a text for the '*red space*'. The negotiations in the working group are activities where knowledge and experiences are transformed into prescriptive text, as standardized procedures with *'red space'* additions. The added text is part of the header of the work description, and can exemplify how this work description as a shared knowledge object evolves. In this specific example the resources introduced in the interactions include non-obvious, problematic aspects of this procedure, practical explanations of how the equipment is set up, and accumulated experience. Work descriptions, in-house procedures as well as standardized PPS procedures, are the result of historically-situated and distributed work, and universal, evidence-based recommendation for best practice (Timmermans & Berg, 2003). Health care can be characterized as increasingly complex, knowledge-laden practices. Among the features of the practice are situational shifts back and forth between efforts to adapt the particular patient's care and treatment requirements and 'packaged', standardized routine procedures.

We have previously reported how different modes of knowledge, personal experience, collective expertise and formalized knowledge, contribute to construct 'local universalities' of a standardized work description (Nes & Moen, 2010). In the empirical example analysed in this chapter, the working group members introduce additional aspects from their everyday practice – that is, known problems and aspects of the actual, available equipment. In addition, available opportunities for how to present additions in the PPS application come into play, forcing them to choose between a short text for immediate display or a longer text requiring additional effort from the future user. In sum, these aspects contribute to the specification of the *'red space'* in the consolidated, standardized work description to be used locally in the hospital. Collecting consolidated work descriptions and making them available institution wide, as part of their knowledge management system, is important. This exemplifies aspects of their knowledge creation processes that may contribute to sustainable practice changes. The outcomes of review and consolidation of the work descriptions locally could be fed into the annual revision with global changes in the standardized PPS-based work descriptions, allowing for wider distribution as knowledge objects that can contribute to transformed practice beyond this specific institution. It is beyond this paper's discussion to elaborate that further.

The unfolding process to consolidate this specific work description demonstrates knowledge production situated in interactions between the working group members, and as interactions with the resources they provided. Professional priorities and values are respected, their contributed knowledge, experiences and information are shared and contested, and, at the same time, they establish consensus about text leading to one consolidated version. This text for the *'red space'* is informed by specific, local experiences and accumulated expertise from their practice, and interpretations of resources like PPS-procedures, current practice at the hospital, local equipment, recommendations and guidelines. This is another example of the importance of practical knowledge and personal experiences as resources to inform nurses how to handle authentic problems, and that such resources circulating in the practice community are preferred (Estabrooks, et al., 2005). Explicating and adding such knowledge to the work description contributes to a more comprehensive and detailed description where the specifics of the necessary equipment is also seen in relation to the larger picture of monitoring the patient with the equipment. As such, work description serves as a best-practice example and a reminder for less-experienced practitioners.

The participants interact in a hybrid, shared space when they review and elaborate additions to available procedures. Providing such socio-spatial locations for interactions in the workplace is important and productive for knowledge creation that contributes to evolving object construction for change and practice transformation (Hakkarainen, et al., 2004; Macdonald, 2002). To develop their practice competently, the providers sort out competing accounts when they pay attention to an array of evidence, not just from research (Kitson, 2002). Drawing on the evolving negotiations to consolidate the work descriptions related to 'thoracic drainage', we see example of how participants interact with colleagues and with artefacts to exchange perspectives, introduce personal experiences, access collective expertise and knowledge to explicate how to perform core aspects of their work. There are combinations of (a) *personal experiences,* presented as a way of doing the described work, (b) *collective* expertise reflecting current, accumulated practice, presented as practical knowing, common-sense statements or how to use equipment, and (c) *research-based knowledge*, expressed as reference to national/international recommendations and, sometimes, published papers and books (Nes & Moen, 2010). As reported across explored processes to consolidate work descriptions as shared knowledge resources, the interplay of knowledge types and practicalities drives them to settle for one version.

Therefore, such knowledge and experience are resources for negotiation and talk and can contribute to maintaining their own as well as create mutual accountability (Nes & Moen, 2010; Timmermans & Berg, 2003). Their interactions show commitment to practice according to a consolidated work description in the hospital while maintaining professional accountability in their work. Playing out towards transforming practice, the consolidation of work descriptions exemplifies resources for everyday practice as part of the organization's knowledge management resources.

CONCLUDING REMARKS

In their evolving interactions when they consolidate work descriptions, we get a window to explore health care providers' considerations and creation of new knowledge objects. The new knowledge objects explicate further how to perform certain work. The situational applicability is constituted in shifts between differentiated, individualized care and 'packaged' standardized approaches, further adapting a knowledge object to the particular patient's care and treatment requirements. Deployment of evolving knowledge resources to support safe, high-quality care stimulates change in the systems of care. As traditional conceptions emphasizing the habitual and rule-governed features of practice are challenged, an exploration of professionals' interactions with evolving knowledge objects in everyday practices is warranted. Observations in this study point to what counts as good, robust and supportive evidence in consolidating work description. Adding to resources expressed as research-based knowledge, collective expertise, or individual experience provided by the representatives from units involved in patient care, we see reference to non-obvious, problematic aspects of this procedure, practical explanations about how the specific equipment is set up, and accumulated experience of what may go wrong or be problematic.

Ensuring easy access to and active use of shared knowledge resources to approach patients' clinical problems informed by the best available, updated knowledge and systematized experience is a significant challenge in any health care organization. Following general knowledge society arguments, knowledge practices move away from traditional embodied and habitual actions since specialization pose new challenges, different questions, and are likely to arrive at different sets of meanings (Nerland & Jensen, 2010). In their interactions, we see their talk about practice as performance of 'packaged' procedures and differentiated practice, common to notions of knowledge work as solving ill-defined problems and engaging in constructing knowledge, in a practice that may seem increasingly fragmented, but also growing in sophistication and complexity. In such situations, availability of standardized work descriptions may be a tool and resource to ensure access to updated knowledge, accumulated experiences, expertise and routines across time and space to ensure health care quality and patient safety. Here are challenges and tensions to be further investigated. Specific elaborations of work descriptions that aim to regulate activities in the hospital, in interaction with current operating rules, traditional division of labour, and multiple views about the tool by collaborating professionals, should be carried out.

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