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KP-LAB Knowledge Practices Laboratory – Report on outcomes of empirical studies

Anders Mørch, Kathrine Nygård, Renate Andersen, Shazia Mushtaq, Damir Nedic, Espen Olsen, Trond Eiliv Hauge, Gunn Vedøy, Svein Olav Norenes, Anne Moen, et al.

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Abstract	<p>This deliverable has been produced in the context of the Knowledge-Practice Laboratory (KP-Lab) project. KP-Lab focuses on innovative practices of working with knowledge in higher education, teacher training, and workplaces. Participants of WP10 are University of Helsinki, University of Oslo and Pöyry Forest Industry representing both researchers and practitioners. WP10 explores knowledge practices in workplaces to understand more of the ways professionals create, use, communicate, and embed knowledge in their work. Such understandings will be made available for subsequent problem-solving in individual and collaborative knowledge advancement. In a longer term perspective this allows to explore professionals' knowledge creation and production processes during boundary crossing between workplaces, from workplaces to education, and from higher education to workplaces.</p> <p>In this deliverable we report empirical findings from the case studies that are currently active in the portfolio of cases. We draw attention to aspects of <i>artefact production</i>, <i>knowledge creation</i> and <i>practice transformation</i>. In our studies knowledge-creation and transformation of practice rests in the interplay of tools, activities and actors. In the cases reported here, the tools provide either a) arena for productive interactions and knowledge creation, b) resources for knowledge creation and practice transformation or c) means for data collection and analytic work. The activities points to many examples where new structures of participation in knowledge work are exemplified as boundary crossing or horizontal movements as professional contribute their expertise to solve open-ended problems.</p> <p>The findings in the cases studies reported here will also be a resource in the continuation of work as more integrated studies; leading and satellite studies with extended pilots. In addition, the outcomes of the studies can feed into refinement of process-sensitive methodologies, exploitation and refinement of the KP-Lab Reference Model and elaboration of pedagogical models for open-ended, object-oriented inquiry as explained in pedagogical R&D in the revised research plan.</p>
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1.0 Introduction

The research and development activities in WP10 focus on knowledge practices in workplaces and the networks the workplace is part of. We explore new activities in the making, as they constitute themselves in contradictory interests or new patterns of activities across institutional boundaries where the object of design ranges from a single tool or technology to complex models of work activity. The cases can give insights to historically new forms of knowledge production. This ranges from cases in technology-rich, knowledge-intensive communities like forestry engineering, software development, and health care to virtual, 3D environments, nanotechnology and adaptive informatics.

Across these cases the focus is open-ended problems, approached by a mix of tradition, routines and innovation. The emergent knowledge creation and tool-mediation produce new knowledge artefacts (KP-Lab, 2008a). The work is organized as parallel lines of activity:

- 1) empirical research and practice development by assessing evolving knowledge practices in selected workplaces in situ. The empirical case studies focus activities in hybrid shared spaces (combination of ‘in space’ (virtual environments) interaction, f2f interaction and f2space interaction).
- 2) technological research and development, where we explore tool use for enhanced knowledge practice in the technology rich workplaces and networks they are part of. Participation co-design processes (design, testing and evaluation) for KP-Lab tool in several Working Knots is the most important activity and also the efforts to establish and refine the emerging KP-Lab Reference Model.
- 3) contribution to the knowledge creation perspective based on analyses in the empirical case studies, review of evolving Knowledge Management approaches, and process sensitive methodological approaches appropriate for studies of knowledge practices in workplaces.

WP10 has two foci in the current case studies: 1) tool-mediated knowledge creation leading to practice transformation over time and 2) Knowledge practice – knowledge production in leading edge research fields, as listed in the table below.

Table 1: overview of foci and case studies

Focus	Case study (number relate to appendix D3.2.2)
Tool-mediated knowledge creation leading to practice transformation over time	10.1 “Knowledge Management for Internal Communication and Customer Relations (KIKK)”
	10.2 “Mediating tools in teachers’ professional development and institutional change (Ullern case)”
	10.3 “Knowledge creation and production processes in transforming social practice (Ahus case)”
	10.5 “Change Laboratory - Activity System Design Tool”
	10.6 “Virtual Mill – Networked working practice at design work”
	10.4 “Interdisciplinary Knowledge Practice in Nanotechnology”
Knowledge practice in leading-edge research fields	10.7 “Adaptive Cognitive Systems”

The cases of ‘tool-mediated knowledge creation leading to practice transformation over time’ have longitudinal design to explore and contribute insight about evolving knowledge production in the specific workplaces. The cases of knowledge practice in ‘leading edge research fields’ focus on instrumentation and accumulation of knowledge in evolving tool

infrastructure, and technological possibilities offered by semantics and meta-data to support knowledge intensive practices. These studies illustrates how knowledge develops; created by and accumulated in tools, in interdependent, evolving processes, and how semi-automated semantic modelling can take place as dynamic, associative, self-organized interaction of human and technology.

2.0 Summaries – across the cases

In this deliverable, D10.4, we will point to findings from the case studies. These reports are written as summaries from the cases reflecting the cases' different contributions. To start with, let us point out that material from the cases of knowledge practices in work places are also reported for “transformation of practice”, “productive interactions in knowledge creation” and “tool use” clusters in D8.4 (KP-Lab, 2009).

Before going into the different case-reports we will elaborate on the methodological approaches and briefly summarize some insights found across the cases reported here. More elaborate discussions of these cases as part of the transformation to research clusters with integrated studies are found in D8.4 (KP-Lab, 2009).

2.1 Methods

In the case studies reported in this deliverable, we combine longitudinal case design with interventionist approaches under the broader umbrella of Developmental Work Research (DWR). This implies that the methods of research and the methods of development intertwine. The emphasis is to the practitioner, their object of work and activities they are involved in towards practice transformation.

Our research approach takes the socio-cultural approach as an analytic framework and given the DWR perspective we argue that these case studies draws from the perspective put forwards as ‘expansive learning’ (Daniels, Cole, & Wertsch, 2007; Engeström, 2001). Approaches to expansive learning are well suited to explore emerging, historically new types of work. This is the case where professionals’ approach open-ended problems and engage in activities that are not as stable more well defined ahead of time. Central features are

- a) *transformative* – radically broadening the shared objects of work
- b) *horizontal* – create knowledge and transform activities by boundary crossing and new configurations in multi-activity terrains
- c) *infrastructural* – often unnoticeable, but anchoring and stabilizing activity to sustain and make multi-activity terrains knowable and liveable (Engeström, 2007, p. 24).

Across all cases the emphasis are exploring / identifying / studying knowledge practices over time, tool-mediation and developmental challenges. Findings help “ground” requirements empirically and contribute analytic insights about tools in production processes for knowledge creation and practice transformation, by co-design and experiments with KP-Lab tools and as ongoing appropriation of 3rd party tools. The cases include interventions to scaffold user activities and attempts to adapt the institutional change processes. The methodologies include

- a) Change Laboratory® methodology supported by ‘Activity System Design Tool’ (ASDT)
- b) Participatory Change Processes (PCP) using Agile Methodology and Participatory Design
- c) Ethnographic studies of ongoing, unfolding change processes, e.g., “history does the intervention”, where knowledge – loaded tools scaffold for practice transformations.

Change Laboratory® is an interventionist approach explicitly connected to expansive learning and focus to design of and (re)-creation of new social practices. PCP approach uses DWR ideas enriched by or combined with participatory design (PD), evolutionary prototyping (EP) and user-centred design process techniques from software engineering in collaborative design

and creation of technology-based artefacts. These approaches are adapted to local context and opportunities, and emphasize end-user development and sustained participation. They facilitate design and redesign of activities by participants in multi-disciplinary networks of collaboration where the object of design ranges from a single tool to complex models of work activity. More elaborate descriptions about these methodological approaches are available in D10.2 (second revision), several authentic deliverables (papers, academic reports and presentations reported as dissemination) and in the case descriptions in chapter 3 here.

To guide the analyses in the cases we have applied the multi-level analysis approach with micro, meso and macro level data spanning different timescales (Ludvigsen, Moen, Mørch, Lahn, & et.al., 2008). In the cases there are interactions between the empirical level (micro level data), intermediate representations (meso level data) and the developmental trajectories pointing to longer-term, historic changes (macro level data). The full potential for cross case comparisons are not fully exploited here. To complement the illustrative cross case examples, we refer to D8.4 since most of the cases reported here are discussed there as well. More details about the analysis strategies are also reported in the case descriptions in chapter 3.

2.2 Findings - cross case examples

The knowledge construction and processes of creating, developing and extending shared artefacts takes multiple forms towards transformation of practice in the reported cases. In an attempt to point out some contribution from the reported case studies, attention to *artefact production*, *knowledge creation* and *practice transformation* are helpful. A core premise of KP-Lab is to study knowledge-creation and practice transformation in the interplay of tools, activities and actors (KP-Lab, 2006). In the cases reported here, the tools provide either a) arena for productive interactions and knowledge creation, b) resources for knowledge creation and practice transformation, and/or c) means for data collection and analytic work.

In the leading edge cases, the available and emerging advanced technologies provide arenas to investigate their open-ended inquiry and efforts to tune and transform their tools. In the case to develop ASDT (section 3.5) the focus is experiences to develop an arena for collectively explicate, model and expand practice. In the cases of ‘globally distributed design work – virtual mill’ (section 3.6) and ‘knowledge creation and production processes in transforming social practice’ (section 3.3) the available knowledge infrastructures provide resources for knowledge creation and transformations following new structures of participation and division of labor. This points to knowledge management infrastructures including support for ‘knowing in action’ as pointed out in D10.3 (KP-Lab, 2008b), and ICT tools’ potentialities as infrastructures for knowledge workers point to how knowledge artefacts can lead to knowledge creation and practice transformation.

For our comparisons it is also helpful to differentiate between two important aspects of how the tools play out in the activities. That is as 1) conceptual ideas of certain technological features and 2) implementation of a technology’s user interface and functionality. In some of the cases they produce new activities and experiment with conceptual artefacts to model a future practice. For example, an example is the SSP-wiki discussed in section 3.2 the conceptual idea of SSP/KPE is used as scaffolds in inquiry-oriented reflection in the ongoing development of educational leadership. Creating conceptual artefacts to foster knowledge creation and transformation is also discussed in the examples that use ASDT to focus on developmental tensions, in section 3.5 and 3.6.

The intermediate representations as part of the agile approach to create proof-of-concept of a new CRM system discussed in section 3.1, point to incremental changes that is adaptation of tools and practices. This proof-of-concept rest in the processes of ‘mutual development’, ‘co-configuration’ and ‘evolving artefacts’, and was actually implemented in a Web 2.0 prototype.

Also, the processes to customize work descriptions and design an interactive, web-based learning environment are examples of artefact production where practitioners mobilize and externalize different types of knowledge, discussed in section 3.3. In these efforts to articulate we also see creation of new knowledge and modifications of work descriptions (i.e. artefacts).

In the two leading edge cases reported, we see how experimenting with the available tools and combine them in new ways leads to accumulation of knowledge in the tools and by use of the tools, i.e., instrumentations expands and transform their practice, in section 3.4. The study of ‘adaptive cognitive systems’ points to meta-data and semantics of artefacts as new possibilities for user communities in interpreting, sharing, applying, and creating knowledge with technology. By advanced models and adaptive informatics they explore how to discover and analyze complex patterns when experts engage in active negotiation and interpretation of meaning grounded of their prevailing practices and epistemic objectives, in section 3.7.

Lastly, we will point out that findings from these studies contribute to understand transformative features, as broadening the shared object of their work. This is also pointed out as productive interactions for knowledge creation and practice transformation in D8.4 (KP-Lab, 2009). Further, new structures of participation in knowledge work are exemplified as boundary crossing or horizontal movements when professional contribute their expertise to solve open-ended problems. Examples of this can be seen in the discussion in section 3.1 where customers play a more active part for software development, or in finding from the globally distributed design work (cf. section 3.6). The findings in the cases studies reported here will also be a resource in the continuation of work as more integrated studies with leading and satellite studies with extended pilots. In addition, the outcomes of the studies can feed into refinement of process-sensitive methodologies, exploitation and refinement of the KP-Lab Reference Model and elaboration of pedagogical models for open-ended, object-oriented inquiry as explained in for pedagogical R&D in the revised research plan.

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3.0 Findings from the cases in WP10 portfolio

In the remaining of this deliverable we present findings and outcomes from the case studies that has been part of WP10's program of investigations. The cases are presented as the team of researchers actually involved in the case has written them up. As the reader may see, most of these cases are either presented as core cases or extended abstracts as part of D8.4 (KP-Lab, 2009). The cases are more elaborated and detailed here.

3.1 Identifying knowledge creation practices in industry based on developer-customer relations in software product development (KIKK)

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The KIKK case is about knowledge practices in a software house. The initial aim was to understand and give advice on their current knowledge management practices. This was expanded to a more general objective to understand the relationship of knowledge management and customer relations and finally also included analyzing a trend in the knowledge-based economy (knowledge society), namely the move from passive to active customers in terms of contributing to product development. We found that existing (in house) knowledge management models could not give an accurate picture of the knowledge practices that went on in the company. We proposed a new model based on an invitation from the company to give advice on their current practices. We implemented the model by a proof-of-concept prototype. It is an example of user driven model of knowledge management. The practice in need of change was an older model of knowledge management that did not take knowledge creation outside the company into account for a full understanding of the knowledge practices relating to the company. The company had very close relations with some of their customers, in effect extending the bounds for conventional knowledge management scope of analysis. We had to include the practices of interacting with customers as part of the unit of analysis as many of the customers were key stakeholder in the product development process.

In the current descriptions of this case we put together contributions that have until now been put in different documents (reports, theses, publications, presentations). We address the following issues: case description, system building efforts, research methods, data examples, analysis and findings, and implications for KP-Lab environment and knowledge practices in general.

Introduction

Case

We have collected and analyzed data in a software house in Norway (referred to as company) for a two years period. The company is engaged in commercial software product development and develops and sells project planning and management tools and provides consultancy services in using these tools. At the present, the company employs 25-30 people, but it is rapidly expanding their staff and search out new marketing share. The main market has been the Nordic oil and gas industry. To expand to new markets, in particular building and construction, the company has started to change and improve its knowledge management practices regarding customer relations. The company's customer relations rested largely on oral and personal connections. These practices are time consuming and not aligned with the goal of serving a growing market with diverse customers.

The company is known for their adaptive product development philosophy, i.e. close interaction with customers to develop tailor-made products (Andersen & Mørch, 2007; Mørch, Nygård & Ludvigsen, 2009). Customers were encouraged to report problems, innovative use, and local development to the company. This is supported by communication

and information sharing tools (Grudin, 1995), which started with the telephone, then mail, later extending to a Helpdesk interface, more recently a complex Customer Relationship Management (CRM) system, and most recently a Web 2.0 prototype. Despite the effort involved in developing new functionality for talking about existing products, such functionality is highly valued by both developers and customers. This benefits the company in two ways, helping to maintain loyal customers and reaching out to new ones.

The first attempt to improve knowledge management practices involved installing a Helpdesk function, but it did not work well (little used). The goal of this system was to allow customers to send email like requests when they needed help with one of the products instead of using the telephone to contact one of the consultants or developers directly. The information could be organized into a database of functional areas and experts in those areas would attend to the requests, as they emerged, somewhat similar to the AnswerGarden family of systems (Ackerman & McDonald, 1996). Instead of first having to go through an arbitrary contact person (as seen by the company), the customer's request would be first organized by an automated system and the brokerage and trouble shooting time would be taken off the shoulders of the employees. The interface to the Helpdesk system was very simple (did not solve the complex problems of handling requests appropriately) and a reason why it was not much used. The customers found it more convenient to contact the persons they knew from before, since the time they purchased and installed the project management tool.

The second attempt was an interactive web-based knowledge tool (web portal for short) to be integrated with a recently purchased CRM system that the company planned to be a communication hub between the two national offices, a link between consultants in the field, and to support customer interaction (Nygård & Mørch, 2007). We entered the company in conjunction with this initiative and were involved in the attempt to build a prototype of the web portal that was tested in the company by its employees (Nedic & Olsen, 2007). It was built on the help desk idea (easy to use), but using a different technology to leverage a new type of interactive systems that many users are familiar with nowadays (Web 2.0). The project stranded when we were not able to successfully integrate the portal with the CRM tool (a vendor product that was not open for integration with third party tools without extensive debugging and work around).

The partial failure of these two different efforts of supporting knowledge management calls for a deeper analysis, which includes but is broader than the analysis of the development and use of new software tools within an organization. It is by now clear to us that the tensions between the different developmental practices could not be solved by one type of solution alone. The problem calls for solutions at different levels, involving both organizational as well as technical components, and combining information sharing support (Web 2.0) with user toolkits (design environments) for end-user development (Fischer et al, 2004).

System building

We have contributed to system development at the support systems level by engaging a process of collaborative interaction with users in the company. The motivation for this work was to design a web portal to organize the rapid growth of information and to improve the communication both internally and externally at the company. The company that we collaborated with experienced expansion of the working staff, as well as in the customer base. Because the requirements for the web portal were uncertain, the development demanded a lot of communication and collaboration between us, as developers, and the company. With help from the Agile Methodology and Participatory Design we were able to clarify the requirements and to overcome the problems during the development (Nedic & Olsen, 2007). Figure 1 shows, the steps of the researchers' development activity: design workshop, scenarios, and iterative web development.

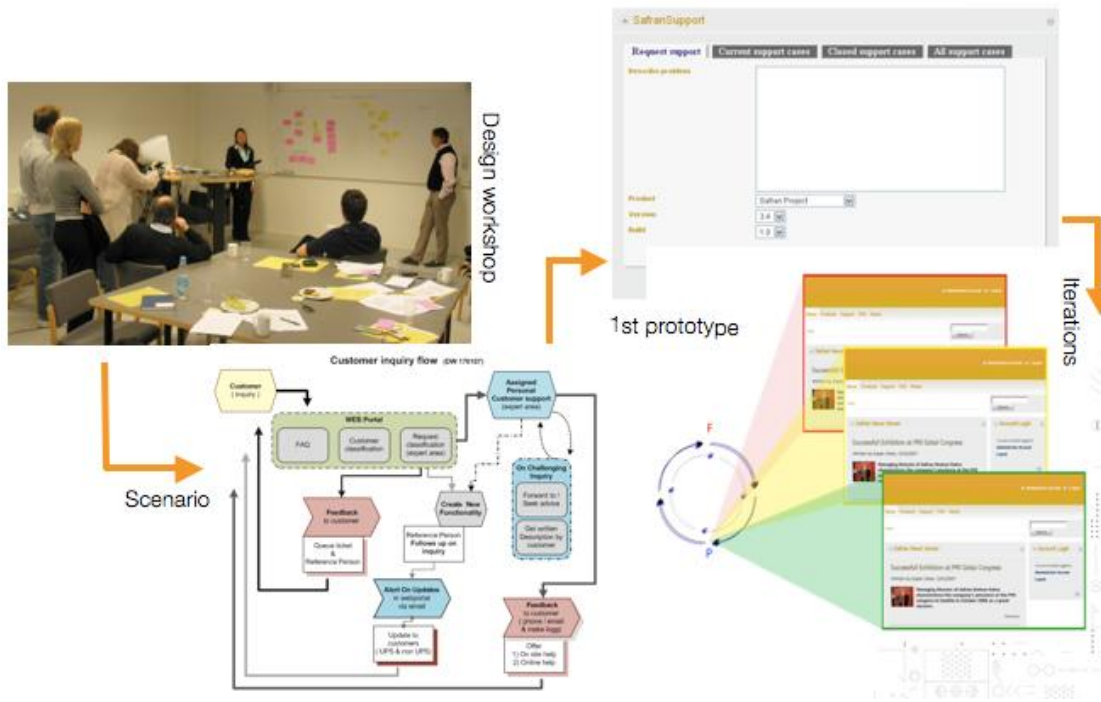


Figure 1: Development activity: Design workshop, making customer interaction scenarios, programming web prototype with user involvement using the agile method.

Based on this we designed and field-tested a Web 2.0 prototype for improved user interaction. This is a ‘proof-of-concept’ for involving external stakeholders (customers) in interaction with the company. It allowed us to experiment with means for communicating problems and solutions regarding modification of existing products created by the company, using a WIKI-like interface. This should be seen in light of the tradition of building customer relationship management systems, which has a longitudinal time span. It started with the telephone, which was over the past 15 years gradually replaced by e-mail, then Helpdesk, and now vendor specific Customer Relationship Management (CRM) systems. These systems accomplished in the past what we have tried to address today (by a first, crude prototype), taking into account the emerging trend of increased interaction by active customers and user driven innovation (von Hippel, 2005).

We have especially utilized Agile’s Extreme Programming method as the developing technique. We argue that by applying this method in the given context, we attained the necessary foundation needed for the successful realization of the project. In addition, in situations where we supplemented it with techniques from Participatory Design; we gained a better understanding of the components to be made.

Research methods

We followed a qualitative approach. We have used interviews, observation, and video-recorded workshops and analyzed software artifacts and documents pertaining to software development activities. The body of data is 10 ½ hours of video material from 11 informants.

The data is approached as dialogues in order to grasp the meaning creation that is constructed in the situations. The informants draw on their experience from everyday work practices and provide accounts for activities history (Scott & Lyman 1968) by presenting narratives of the relationship between product development and the company’s. The accounts include clarification, explanation, context descriptions, elaboration, and justification in specific situations. Descriptions of different aspects of the context are used to provide evidence and link together what is treated as historical events and significant changes in practice. This type

of talk is generated by the participants in order to be understood, and thus follow the roles and norms of participation in interviews and arranged workshops.

We also identified the sub-processes of the product development process studied. We used template analysis as part of open coding to identify the sub-processes between customer activity and professional system development activity. Template analysis is the process whereby “the researcher produces a list of codes (a template) representing themes identified in their textual data (King, 1994).” This is both a top-down and bottom up process. After identifying the initial set of codes, as a first guide to search the data we did a bottom up analysis, letting the data “talk for itself.” Reiterating by regrouping data (bottom up) and renaming labels (top down) we ended up with a quite stable set of categories that served well for the data we report in this case.

Defining codes is to label a section of text with a code in order to index it as relating to a theme or issue in the data that the researcher has identified as important to his or her interpretation (King, 1994). We had the research questions in mind the first time we went through the data, but in the second round of selecting data we categorized it accordingly. The categorization of “outer loop” (a broad view of system development in the company that also includes customer activities like end-user tailoring and issuing improvement requests) and “inner loop” (in-house system development activity) were used as “high-level codes,” and may be connected with what King defines as hierarchical coding. The set of codes we used were: Adaptation, generalization, improvement request, specialization, and tailoring.

Data extracts and analysis (illustrative examples)

Extract 1: Types of Improvement Request

In the first excerpt, the focus is on how a developer (informant) judges the Improvement Requests of the customer. This includes making a power decision as to what kinds of Improvement Requests to consider. The power to judge whether or not a customer Improvement Request should be accepted lies in the hands of the company’s professional developers. This excerpt does not go into detail about how exactly these Improvement Requests enter the company, but it does elaborate in what way the customers ask for Improvement Requests.

Informant: Often when they (the customers) want Improvement Requests they ask me if I can make a change (to the existing product), according to some needs they have. In addition they put it (the Improvement Request) into a list we have on the Internet. We receive a lot of Improvement Requests and some of them are actually such good ideas that we want to integrate them into our products. And there are other ideas that are really bad. There are also some ideas that are not so good (but they are doable), therefore we incorporate them if they pay for it. When doing this we make special libraries for that particular customer. Then this does not become a part of the system (the product).

Improvement Requests turned out to be an important activity for communication with the company, requiring less technical expertise than Tailoring. Excerpt 1 is an example of how customers propose changes to the company’s products without doing any local development. Excerpt 1 shows that an Improvement Request is one of the prerequisite sub-processes of Adaptation. It is when a professional developer creates a new feature for an already existing product in accordance with the customer’s demands. At the end of this excerpt, the informant introduces the theme of how they get good, possible (doable) and bad ideas for further development. If an idea is labelled *good* it is accepted as is. When an idea is categorized as

possible it means that the idea is plausible, but will not become a part of the general product. It might be accepted under contract (with payment), and turns into a local Adaptation. Finally, an idea labelled *bad* is rejected outright. Implicit in this example is the assumption that the company's employees are the ones who judge whether the Improvement Requests are *good*, *possible* or *bad* and have the freedom to make those distinctions.

Extract 2: Spread of user innovation

The next extract illustrates how the company takes advantage of the local initiatives to improve the products. The extracts illustrate that there is a connection between adaptation and generalisation, according to how generally useful specific solutions are distributed: *local spread* and *global spread*. Furthermore, the following software engineering terms are used in the extracts below: *patch*, *user option*, and *version/product*. Patch and user options are adaptations specifically made for a single customer, whereas a version means the solution will be incorporated in the next release of the product and available for all customers. The conversation is with a developer and shows how a specific solution (available for one customer) can be made into a product available for all customers.

1. Interviewer1: Do you have other examples of customers initiating new functionality to the product?
2. Respondent2: Yes, we have done it for Kværner, ABB...[two large European engineering and consultancy companies]
3. Interviewer1: What sort of new functionality did they want?
4. Respondent2: I don't remember. It was years ago. I know that when they bought the product they had specific demands that were originally not part of the product. But we wrote it in the contract as functionality they wanted.
5. Interviewer1: Ok, so it was a part of the contract?
6. Respondent2: Yes, they wanted it within a specific time period. Their requests were rather demanding regarding what they wanted us to do.
7. Interviewer1: Was it an add-on made specifically for Aker Kværner?
8. Respondent2: No, it became a part of the product. Yes, it started as a patch, what we call a user option.

Interviewer1 asks the respondents to give examples of customer-initiated product development. Respondent2 responds by naming two large European engineering and consultancy companies. Interviewer1 asks the respondent to specify what kind of new functionality was implemented. The respondent answers by making a reference to time ("*It was years ago*"). This indicates that contributions from customers that are accepted for inclusion into the general product do not occur very often, and are mainly initiated by large customers. He explains how a major request for change led from "user option" to "patch" and eventually "*became part of the product*". In the contract it is specified as a user option. The developers use the term "patch" to mean a plug-in to the product when it is run. Updates and fixes are incorporated this way. When a patch is integrated into the generic product code and made available for all customers it is "part of the product."

The narrative illustrates global spread, an adaptation that becomes available to all customers. The transition from local spread to global spread, which in this case involved new licenses and local updates, is captured by the following abbreviated answer by Respondent2, in essence recapitulating the whole process in reverse chronological order ("*No, it became a part of the product. Yes, it started as a patch, what we call a user option*").

Major findings

The extracts taken together show there exists a path from adaptation to generalisation that is subject to multiple factors: local proposals for change, acceptance with or without payment, different stages for the artifact to pass through in the company (user option, patch, version) before it can be packaged into a generic product. In this process, both the customer and the company will benefit, despite the additional developmental work and expenditure involved, and the possible loss of owner rights to specific solutions.

At the conceptual level we have contribute with new ideas and concretized existing ideas. In particular:

- *Mutual development*: Dynamics of expanding to new markets and adapting to individual customers' needs (Andersen & Mørch, 2009; Mørch, Nygård & Ludvigsen, 2009);
- *Co-configuration*: Giving an example of developers, products, and customers co-configuration (Engeström, 2004; Victor & Boynton, 1998);
- *Boundary crossing*: Giving an example of interaction between developer activity system and customer activity system mediated by shared artifacts and partially shared objects (Nygård & Mørch, 2007);
- *Evolving artifacts*: (Fischer & Ostwald, 2001; Mørch, 2003; Pollock & Williams, 2008) Following the development of shared artifacts (software products) as they are part of mutual development, co-configuration and boundary crossing;
- *Knowledge management (KM)*: Identify strengths and limitations of KM systems; the degree KM can and should human experience be formalized in system representations, pointing to inclusion of knowledge in different representational modes (Mørch, Moen, et al., 2008).

When compared to the ideas and principles underlying KP-Lab our case provide an interesting example of the principle of knowledge advancement around authentic problems. Knowledge advancement around shared objects and artifacts (authentic problems) in this case is *asymmetric* in the sense that participation in developer activity is different from user-design activity when evolving shared objects and artifacts. Professional developers work directly on the product (source code builds), whereas end users work on local instances, creating modifications and requests often in high-level (user oriented) languages. This shows an asymmetry in tools, actions, and decision-making. It is the professional developers who decide whether or not a customer proposal for modification to the shared product should be accepted or not. This is not unlike how it is done in open source software development and collaborative writing of scientific papers because it is the core developers and lead authors who can exercise decision making power of other developers' contributions, thus creating an unbalance (asymmetry) in the activity around shared objects.

It is also interesting to not that the developer-user relation explored in this case goes beyond the expert-novice distinction in psychology, since customers are also experts in the practice domain (i.e. domain expert users, super users, etc.). It is also different from some of the other KP-Lab WP10 cases where end-users are *trained* as professionals, e.g. PhD in science. Differences and commonalties of these two complementary developer-user relations ought to be explored further, to drive the research on knowledge practices in professional contexts one step ahead in subsequent work.

Open issues and discussion

The KIKK case shows that workplace settings are in some important ways different from educational settings. They are to some extent the “providers of authentic problems” that should not be overlooked when bring authentic problems to bear on education. The issue is

what to simplify and what to keep intact in order not to “water down” the authenticity of real world problems. The findings obtained from the KIKK case (and most of the other WP10 cases) help us in this regard to single out those qualities of a work practice that can benefit direct import and simulation in the classroom, and those qualities that need adaptation and/or simplification before they can be adopted. In any case the adaptation process should be part of the pedagogy as the rationale for a chosen problem to simulate. If instead authenticity is treated as a “black box” (without means to get the at the rationale), the effect on teaching may not reach its expected outcome to bridge the distance between academic and practical knowledge.

When it comes to transformation of practice the KIKK case contributes with an example of practice transformation from conventional software engineering to an engineering approach that involve active customers (selected end users). The benefits KP-Lab can draw from this is as an example of a knowledge practice in industry where end users take an active role and extend the boundaries of the organization, not only by providing input to requirements, but also as contributors to innovation in their capacity as experts of how software products can be used in new and innovative ways.

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3.2 Mediating tools in teachers' professional development and institutional change

Transforming practices in educational leadership

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This report describes key elements, visions and activities in a challenging school-based development work on changing leadership practices in an upper secondary school. A new top-level leader team responsible for the development of teaching and learning is introduced and followed up by a KP-Lab research team in 2007-08. The research design is developed in collaboration with the principal and school leadership group following Development Work Research (DWR) methods adapted to the local context. Conceptual and technological tools are introduced as mediating means for workplace analyses and new leadership practices. The case study report focuses on how educational leadership evolves as a shared object of development at the institutional level and how practices are transformed and adapted to intermediate teacher team levels in school. 3rd party technologies (Shared Space wiki, VideoPaper) are utilized in the change process. As leadership practices are changing in this school they follow a complex path of transformation both temporally and socio-spatial facilitated by a set of local and external tools.

Introduction

The case study focuses on how educational leadership evolves as a shared object of activity leading to transformed practices in an upper secondary school. In a participatory intervention research design inspired by the framework of Developmental Work Research (DWR) and approaches of expansive learning (Engeström, 1999, 2001; Daniels et.al. 2007), a set of 3rd party technologies were introduced to support the change processes. The technologies included institution specific tools, i.e., *Fronter* (local learning management system), *Shared Space* (adapted web2.0/wiki-platform) and *VideoPaper* (a multimedia web document developer). The intervention aimed to support a new top-level leader team in developing their practices during the school year 2007-08 by use of conceptual tools for leadership and school development, and supportive advanced technologies. Such practices included teamwork, collaboration, inquiry-oriented processes of self-evaluation and analyses of former research and development in school. As the case evolved, support to teachers in developing professional teamwork was added.

The research study focuses on changing conceptions of educational leadership as practices evolve in dynamic interplay with tools for workplace analysis, technologies and team discussions. We are particularly interested in 1) how *conceptual and technological tools utilized in the developmental work process* contribute to the transformation of educational leadership practices in the school, and 2) how *socio-spatial and temporal aspects of transforming leadership practices* unfold in the institutional change process.

School history and research context

The needs for tools supporting collaborative and communal sharing of ideas, analyses and design of educational practices, also targeted to institutional leadership, have been identified in collaboration with the principal and department leaders in the school during a series of school-based change initiatives and intervention studies since 2004. In this evolving school - university partnership, we as researchers have been participating in iterative development cycles experimenting with generic tools and studying social and pedagogical practices over time. Teachers have been active participants in the research groups ensuring that interventions include endogenous (teachers, learners, institutional) interests as well as exogenous (researcher) interests.

MetaWiki has been used to experiment with collective knowledge advancement in English as Foreign Language and in Mathematics. In the first iteration, pilot-design experiences with the EnglishWiki showed that the tool provided a subtle structure where learners and teachers easily could construct, link and re-arrange content in and between spaces and pages (Lund, & Smørdal, 2006¹; Lund & Rasmussen, 2008). In the second iteration, introducing the MathWeb, we experimented with a wiki in a subject that historically has been known as a subject where a high number of small and delimited tasks are sought solved individually. The MathWeb challenged and enabled learners to articulate their knowledge in mathematics, discuss solutions, and engage in joint problem solving (Norenes & Hauge, in progress). The third iteration in this on-going collaboration, a team of Mathematics teachers was invited to technology enhanced reflection on their teaching practice by use of VideoPaper-technology.² Pre-designed classroom lessons focusing on student group discussions and explanations of mathematical solutions were videotaped and transformed into web-documents allowing teachers and researchers collaboratively to comment, categorize and analyze the lessons (Hauge & Norenes, 2009).

Current intervention and default scenario

The current research and development design is based on a local plan for leadership restructuring and the previous research on teachers' workplace learning in the school. The aims of development work research at the school level are:

- To support establishing a new top educational leader team in the school that may act as intermediate between the principal, the heads of departments, and individual teacher teams. The leader team has an overall responsibility for systemic piloting, support and follow-up work of innovative classroom practices (support for teacher team professional development was added later on in the process).
- To facilitate innovative leadership practices by use of conceptual tools and advanced technologies supporting teamwork, collaboration, inquiry-oriented processes of self-evaluation and activities for institutional change.

The motives for change reside in the schools' own development history as a school being able to turn around failure to success with regard to the improvement of teacher recruitment and students' learning outcomes. From being threatened by closing down in 2000, six years later it was appointed to a national demonstration school, being rewarded for good leadership and organisational development, teacher collaboration and systematic follow-up work of student learning. Use of Information and Communication Technology (ICT) in teaching and learning is a high priority field of innovation. The social part of the new leadership structure may be looked upon as a step forward in strengthening the common vision and practices of collaboration and leadership in the school. The technological part of the innovation evolved as a possible follow-up work of earlier interventions and was brought forward by the research partners in continuous discussions.

The overall design and work structure for educational leadership in 2007-08, illustrated in figure 1, describes some key components, communities and communication lines being activated in the school change process. The figure shows a simplified picture of interactions between three institutional levels: the classroom level, the department/teacher team level and the educational leadership level. The main object of change as mandated for the new leader

¹ Also reported in KP-Lab WP9, (2006-2007)

² VideoPaper was originally conceived in 1998 through the National Science Foundation project (US) – “Bridging Research and Practice” (NSF # 9805289) to enable researchers to collaborate with practitioners through video. Cf. Beardsley, Cogan-Drew, Olivero (2007). The software is available for free download at <http://vpb.concord.org>.

team is improvement of classroom practice. However, this object of leadership is scrutinized and restructured during the development process in interplay with institutional constraints and contradictions. The question of how to practise leadership through intermediate community levels (departments and teacher teams) and by use of shared tools and objects for change becomes an important issue over time in the project not only for the leader team but for the principal as well. Figure one points to the centre of this challenge, i.e. how tools and objects collaboratively are being utilized in the school development process.

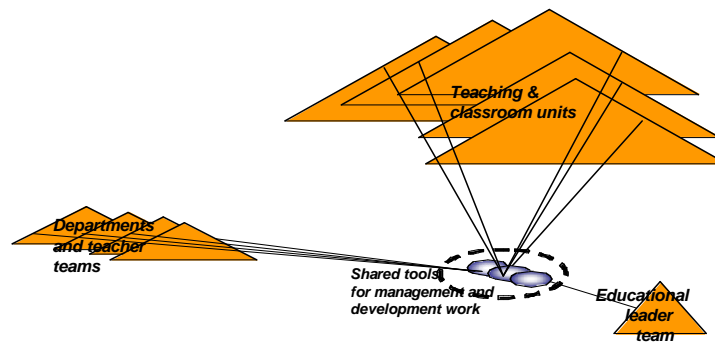


Fig. 1 Key components in the development structure of educational leadership

Research design and methods

The research study is designed in interplay between two activity structures; one is based on the local school initiatives, tools and work structures (cf. figure 1), the other one is based on an external, but participative intervention initiative with new adaptive tools and activities. Both structures aim to support the transformation of leadership practices as a shared object of research interest between the school and the research group. The research design is enabled in conjunction with interests of the principal and the new leadership group, and for the school participants it operates as an analytical support tool for their change initiative. The research design is inspired by the framework of Developmental Work Research (DWR) methods and approaches of expansive learning (Engeström, 1999, 2007; Daniels et.al. 2007), but are used in a “light” context adapted version (cf. Edwards 2005).

The research methodology has been organized around a series of three “developmental work research” workshops with the researcher team, the leader team and the principal as participants. Prior to (also in between) the workshops the researchers collected observational data that was scrutinized in workshop settings by researchers and school participants. The aim was to build upon professionals’ “everyday” understandings of leadership and strategies for classroom improvement, juxtaposing these with reflective, systemic analysis of the ways in which current working practices (or “activity systems”) either enable or constrain transformation of leadership and then discuss possible designs for further actions and development. This three-step model is illustrated in figure 2 involving past, now and future perspectives on work practices. The principal and the research project leader were leading the workshops together based on pre-defined agendas discussed with the leader team. Each workshop lasted for about 4-5 hours and was videotaped. Figure 2 gives a simplified picture of the model.



Fig. 2 The DWR adapted intervention model

The adapted DWR model in figure 2 comprises:

- Mirror data of school practices - empirical data from classroom and institutional practices: Actual statistics, investigations and reports produced by the school itself, video recordings from classroom practices and workshops (e.g. MathWeb project, VideoPaper project), and field notes from meetings with the leadership group.
- Conceptual and technological tools/models: Overall visions, strategies and aims for school development, national curriculum guidelines, periodic staff meeting plans, digital support structures for management (Fronter structure), the TPD-model for workplace development (Theory, Practice, Design) (cf. Hauge & Norenes, 2009; Hauge & Norenes, 2009³), and Shared Space (SSp) wiki technology.
- Action designs: Leadership action plans, development plans for student assessment, portfolio assessment and plans for teacher team development.

The workshops were organized to support continuous, juxtaposed processes between mirror data, conceptual and technological resources, and analyses of change initiatives and design. As time passed work in the eL-team changed, influenced by institutional and everyday events with students and teachers in the school, and a continuous team drive of improvement. In summary, the empirical data used for analytical research purposes comprises video recordings of workshops and leadership meetings, field notes, email correspondences, annual school reports, local school websites, action plans and strategy documents.

The analytical framework is based cultural historical-activity theory (Engeström, 1987, 1999; Daniels, Cole & Wertsch, 2007) and activity theoretical studies of collaboration and learning at work (Engeström, 2008). The educational leadership team (eL-team) and its evolving activity system is the prime unit of analysis, and we are looking at how the team is working for the development of leadership in interactions with available tools, support structures and institutional infrastructures. For the purposes of this study, looking at knowledge construction and practice transformation of leadership as a collective phenomenon, the principal is included as an equal member of the team, despite his different role positioning in the school.

³ Further descriptions and grounding of the TPD-model is prepared by T.E. Hauge & S.O. Norenes (forthcoming 2009), *Building capacity for teamwork: Videopaper as a transformative tool for teacher professional development* (Special number of Journal for technology and education).

Major findings - Transformation of practices

The case study reveals a story of how a new and highly motivated work unit contributes in changing institutional practices for school development. We point to two main findings as regards transformation of ideas, practices and tools for educational leadership. The study shows how conceptions of educational leadership are changing as practices evolve in dynamic interplay with planning, task implementation, tools for workplace analysis and collaboration with teachers. The study points to tools supporting the change processes, but also to the complexities of practices involving advanced technologies for the support of professional development practices. The following section offers further descriptions and explanations for the understanding of the changes.

Changing conceptions of leadership

Analyses of group discussions in the DWR workshops and actions taken by the principal and the leader team over time show how educational leadership, as an object of activity is changing and transformed during the project period. In activity-theoretical terms the object of activity moved from a close teacher oriented perspective of classroom work to an institutional perspective on team building and professional development of teachers. Further, the leader team moved from being the prime actor of change collaborating with individual teachers or group of teachers being interested in development work, onto working with teams of teachers at the institutional level as the primary agent of change. As a consequence, the community perspective of institutional change became a tool for strategic planning and a means of fulfilling the overall aims of development. During these transformations we observed how new conceptions of leadership emerged, not at least with respect to tools supporting team development and how work tasks should be divided in and between different institutional levels. Ideas and practices of distributed leadership (cf. Spillane, 2006; Gronn, 2008) and teachers as leaders (Liebermann & Friedrich, 2008; Liebermann & Miller, 2008) were deployed and concretized. These changing conceptions are described through two phases of practice development nested to the three-step workshop cycle.

Development phase I

The starting point for the development of objects of leadership may be illustrated by the following utterance from the principal in workshop 1, where the participants are discussing goals and actions for their development work:

Because, when we established the eL-team, that was a way of thinking, a desire to focus more broadly on pedagogical practice. We wish amid the teachers to work with teacher capacity/professionalism, educational quality, and through that the students are to learn more and they are to complete and pass. Amongst others. This was foremost about educational quality. Then you can say that there are many ways of doing such a thing. One is to collect plans for the curriculum, and examine sort of, are there unambiguous goals in the plans, can we recognize the basic skills, what are the teachers thinking? You can observe teaching practice and examine how is it preformed? That is one way of doing it. What we in a way are thinking in this project is that we choose some areas. Let us say that we choose assessment. And assessment is a very significant term. Subsequently, then we have to monitor, and what issues connected to assessment do we wish to examine? What are you going to highlight, and work with connected to assessment that will give us a better overview and understanding of practices in the school?

The principal is reflecting the inquiry-oriented approach that characterizes the initiation and development of the project at school level. Workshop 1 comes to play a significant role for furthering decisions about goals and actions. *Student assessment* or more precisely *assessment for learning* was decided to be the prime object of development, which historically is grounded in strategic development plans in the school, but still needed to be nurtured and elaborated as a practice. The motive for choosing the object was aligned to the fact that all teachers in the school were already involved in extensive follow-up work of individual

students. However, the content of development plan for assessment was still quite open and needed to be concretized:

- E: Mid term assessment; can perform this without having taken a test. National criteria, many teachers just sit and wait for them. Why are "we" going to do that job? Imply at the contrary that the criteria have to come from them. When it comes to portfolio, we can't forget the daily practice. One idea can be to create an assessment plan together with the students for a year. That can be a learning plan as well.
- S: Design a database with a report on mid term assessment. Think organizational around this. Communicate academic level and growth potential. What are our objects? Everyone must have criteria, they don't. For instance the natural science teachers. Have to have the underlying bricks in place first.
- E: Is of the opinion that they have reached a high level. Many schools don't relate to criteria at all.
- Ra: Refers to E and S and the work with an assessment plan. Points to that students often have a short-term perspective. Important with documentation. Exemplifies through her own experience with a 9th grader. Had documentation on Fronter. Create structure also for students.

Later on in the workshop, portfolio assessment was chosen to be the tool for expanding the object of student assessment and interconnected practices of leadership. Discussions in the eL-team reveal a diversity of motives for the work on portfolio assessment, however, also directing energy to work on what and how in the eL-team.

- E: This is also about how we in the P-team are to work. Dear to think in long terms. We are in a phase where we don't know how to work together as a team yet, and that takes time.
- R: Agree, we have to be clear.
- J: We have a portfolio project that will last for a year, but also a Barcelona seminar. Important that we settle matters quickly because of the time, in all phases.
- R: If we during the day decide that this is the object and this is what we are researching. Then we will state it very clearly. We are to research and be enquiring about this.
- J: Brings in that they already have high ambitions, and that it is possible that they have to reverse something in order to get the proper focus on this project.
- Ra: How do we work with the students?
- R: Important to consider that we are working together with professionals that give us considerable insight, and help to dig deeper into this.
- E: Refers to the staff seminar where there will be presentations related to the use of portfolio.
- J: But, can it be an idea to show the linear run, and that we don't need to do everything at once, and we are entering all the different levels? But the entries to that can vary a bit.
- S: We are not ending the portfolio project this summer, but are working to find a good design to extend the project.

In activity-theoretical terms, the object of leadership in this first development phase of the project was both fuzzy and well defined. It was well defined in the sense that "assessment *for* learning" meant certain institutionalized routines of follow-up work of students. It was fuzzy in the sense that it was difficult to untangle the concept of *learning* and how it was associated with *assessment*. To clarify practices and conceptual meanings of the assessment object a set of portfolio case descriptions were developed by the eL-team members after workshop 1. During the case writing the complexity of the object becomes even more evident, at least for the researchers. Further initiatives were taken trying to cultivate the object by asking the group members to concretize their practices as teachers by writing some short case descriptions about key student portfolio assignments. At this point of the DWR intervention a turning point or shift in leadership perspectives of the eL-team emerged: Going further with such a micro-level analytical task was perceived to move the project into a wrong direction. The approach was assessed to be non-productive for the development of leadership at the institutional level.

Development phase II

The changing perspectives on leadership that emerged between workshop 1 and 2 gradually moved interests and activities upwards in the school organisation and into a collective level. However, the improvement perspective on classroom practices, i.e. focusing on changing practices of student assessment, was still intact as an ultimate aim, but the tools and levels of interactions with teachers were changing directing thinking and efforts towards collective

professional development. Workshop 2 reflects the turning point in the evolving leadership practices that took place in-between the first and second workshop. As part of the changes workshop 2 was organized to explore practices, tools and design of collective teacher professional development going to be fully implemented for the next school year. Questions and problems in implementing the solutions are discussed in relation to watching of a video episode of practices in a teacher team.

S: A very tangible assignment, I figure, is that these teachers (refer to a focus team of teachers) wanted time to work with curriculum and criteria. They have requested a day for that. I feel it would be helpful to work with E again, or one of you others (eL-team). I feel it would be very helpful to be two (.....) and we could try to think of a model for working with focus teams on exactly that. It would be an opportunity to reflect on it and use it as a model for that type of model next autumn. It is relevant for a focus team to be there already from the autumn on. Use methods we have used earlier, what do we do? They probably do much, but some of it is tacit, some of it is good and some is not so good. Design a day like that. They have asked me for it, and I don't think it is a good idea that they just get a whole day for just working. When they are there .. after so many years, then there is something to gain in creating new perspectives for the day.

E: If the idea is to do research on our own practice, we also have to consider what experiences we as a leadership team (..) have from before and what we can develop. You (we) have worked very much with this matter, and you have many useful contributions that generate quite an amount of reflections. If I am to be a process leader in a team, then I have a need to understand processes, build a model, learn how to use and reflect upon it. Explore, think where we have focus, all that. I'm not eager to perform action research on this ... next autumn. That's the way it often turns out to be.

The eL-team is searching for and willing to experiment with tools and methods that can assist leadership practices for teacher team development processes. Their perspective on leadership is evolving during the discussions and their role conception becomes more distinct. The following discussion tells how the leaders are fighting with themselves in understanding the context of their work and how they may exercise leadership:

E: We are in need to know what happens and which decisions that are made in the organization in general. (E is drawing at the whiteboard.) What I was thinking - was to expand this. If we discuss the issue of assessment, then we have assessment in the middle. Then we have an aspect that deals with assessment of learning, one on assessment for learning, and there we have issues concerning legal protection and that what we do is decent when it comes to governing guidelines that we have to relate formally. Another box is systemic understanding, and competencies are connected to this.

S: What do you mean by systemic understanding connected to assessment?

E: Then I think of what we have to relate to and in what manner we have to relate to it. And if we work with teachers about assessment for learning they have to understand, then there have to be competence about where this comes from. What is the connection? Is it something we have made up, or is it rooted theoretically, politically or organizational? Here is an area dealing with procedures. But underneath here we have portfolio, mid term, ICT-assessment, what is a broad base for assessment? In other words, discussions about interpretations of the concepts. Plans we have worked extensively with, where do we see assessment in them? Criteria for assessment. We deal with all these issues that together constitute an area/field, so this is assessment for learning?

S: And then the connection between the two again. Of and for.

E: Yes, it is to dig into what issues in connection to assessment are we talking about? Here we are at different levels in our work, and where we exercise leadership.

While the object of leadership in workshop 1 was aligned to the development of student and portfolio assessment, the object is far more elaborated and connected to activities in the school as an organisation in workshop 2. The object is expanding during the second workshop by becoming more differentiated with regards to the social and pedagogical infrastructure, and interrelated to a new emerging tool for organisational development, i.e. the teacher team model. To illustrate the complexity of the expanding object we chose to follow a discussion of how a group of teachers were commenting a video sequence from their own teaching (the sequence is shown for the eL-team).

S: The challenge in that math focus team. How can we get more students to verbalize their knowledge more often?

E: I was thinking of a comment, and then I think what is the learning outcome like for those who get an explanation, then I think they will move one step upwards, to what extent do they reflect when they explain, what do they grasp? Like, the student – teacher relationship. They see it so clearly in the students. How does it inform their practice?

Researcher 2: They were not able to catch that meta-perspective.

S: That is what I am thinking. The first thing that comes into mind is that here we have two students that don't get it; instead of thinking how can I organize this activity in order to reach everybody? Like, more didactically into the subject.

E: Because if I had explained it, it is not definite that everybody understood it.

Researcher 1: What is important to you, as a teacher is the expectation that you present and explain this subject matter, since then you are confident that you have done your job. You have presented it, and then the students have "learnt" it. Then you are on safe grounds when it comes to documentation. This creates great dilemmas.

S: The obligation of accountability.

E: But there we are, we as leaders here. Aren't we doing exactly the same? But here is the opportunity to facilitate that it is the members of the focus team that explain each other in order to learn. That they take that role in the focus team, and not that we (eL-team) have that function. We are leaders too.

Ra: In a way when you are a pedagogical leader, you are sort of a teacher-teacher, and then you have the same considerations. How is this done teacher-didactically? What kind of leadership strategies do I use to make sure everybody is included?

The episode underlines the dilemmas of being a leader and a teacher at the same time, and what roles the eL-team is following when designing for change. The way of teaching, presenting and explaining subject matter, presented in the video, also becomes a vital part of the leadership discussion.

The next step of the DWR process moved the eL-team into a leading position of two pilot teacher teams who were meeting for the exploration and modelling of student assessment practices. The video recorded meetings were discussed in the final workshop 3 as part of the strategy to expand the practices of leadership and modelling a set of follow-up sessions for teacher team development. The following dialogue takes place:

E: We have to shape a model that can inform us leaders something about what is actually happening in the professional teacher teams. Not just notify them of a project that we will hang along and control, but we also wish to create systems that will enable us to follow up and know. Be tightly connected to the development. I fear that we're not making professional teacher teams, but 4-5 projects. We have structures for leadership practices at individual level and now we intended to create structures and leadership practices to follow up and be informed at team level.

R: Isn't that exactly what we are doing? It becomes a competency; and the object will change as we go along? (We) can say that the log is a tool that we will explore, find something we can document. Then we will see the object. This type of work needs this and that kind of leadership, and this and that kind of method? For me it is another way of gaining control, than just sit and listen. We explore somewhat smaller parts.

E: But we cannot forget that dimension. Our point of departure was to create structures for leaders to follow up teams. That was the point of departure.

R: Can't it be a part of that?

E: Yes, obviously.

R: It can be two things.

E: We have procedures for individual follow-up. We were to create systems for follow up. I just say that we ought to remember that. We have to think that this is a part of an overall system for team leadership, and not five new projects. To have five different focal points can be interesting, we can achieve much effect from that.

Ra: If the object was a more system-based understanding of work in the professional teacher teams then the object moves or develops to become more of a focus upon processes in that professional teacher team or specific objects as a part of process development, but that can vary from team to team?

The dialogue expresses a concept of leadership quite different from what was brought up half-a-year ago. The leaders are talking about how to identify real practices and knowledge at work in the school, how to document work, and how to know systems, structures and strategies for follow-up of teacher teams. And they are talking about specific competencies and methods of

leadership that have to be contextualised. The discussion moves further on by describing leadership of teachers in a workplace setting compared to teachers' classroom leadership.

- S: We now have seen two representations of moments. J has been a part of the portfolio teacher team and I have been involved in some meetings in the math teacher team, but I feel like I don't have a clue about what they do on a regular basis. If this were a group of students I would never decided upon the methodology before I knew where the students were. Goals for professional teacher teams are end number one, and I don't have the best vibes. Yes we have to create goals that force us to consider where they are. I have to know where people are. What results would be good for them? What goals do they wish for in this work? In addition we have to formulate goals. What kind of results informs us when we intervene? It was so evident in the math teacher team that was a quite easy one. There we had focus and goals. It is not that evident in the professional teacher teams we have chosen now.
- E: Exactly. Next year the professional teacher teams are to be in the forefront. We have to make the definitions. What is the leadership perspective?
- S: Give support further, or is it.

Leadership is about formulating goals based on practices and competencies of the participants, looking for results that contribute to learning, and designing for developmental support. While talking about goals and visions, the realities at work, use of time and transfer of experiences are also part of the leadership discussion. What is the developmental potential of practices when teachers are fighting with everyday constraints at work, and how can knowledge be transferred between groups of teachers? The following dialogue points to these questions.

- R: Here we have interesting approaches. If time used in professional teacher teams is characterized of forced action, we get little production of knowledge but mostly reproduction. Then we get modest development that other teacher teams can benefit from. Is it that this isn't possible to distribute? If they get additional time to do what they really were supposed to do another time, than we have a problem with the value of transmission. If everybody has to experience these processes, then this has to be more than a pilot project. And transmission becomes more than information. We have to ask the question about what this really is. Do we believe that what they create of process knowledge can benefit others? Maybe it is both? To me is "we" for E and S in the math teacher team another "we" than in J's portfolio teacher team. It is we and us with J, but it is "we" like a school community related to process leadership. That is two different ways. One leadership for academic content and one for process leadership, that creates distinct challenges when it comes to motivation. At the same time it is an advantage that they have to have the focus and the direction. But probably it has to be a sort of methodology. How will this learning happen?
- E: The reason why we focused upon this was the poor results they achieved with their work. We cannot be sure that this is the same for other professional teacher teams. We have to be careful not to generalize to the work of other teacher teams. These were included because they needed an extra push, to receive additional instruction. But it is important to consider on what is transmission, what are good examples, where lies potential for growth and how can we find it and lead it?
- R: The reason for exploring the collective in teacher teams is that we don't know which teacher teams that work or not. We have a clue, but we don't know for certain.

The eL-team members have no clear answer to how the knowledge transfer process should be monitored between teacher groups, however, they are intuitively responding to the problem by adapting their approach to existing competency differences among the teams. And they need to learn how teams are working before making any decisions.

Cross-summary perspectives

Table 1 below summarizes an overview of changing conceptions of leadership running through the DWR period framed by the workshops 1-3. Descriptions are built on the observed leader team activities being shaped in interactions with other professional communities in school, organisational structures and practices. In activity-theoretical terms, the object of activity observed through the DWR process is constructed in interplay between the members of the eL-team, institutional tools for planning and monitoring practices, tools for analyzing practices, and a varied set of rules, communities of practice and divisions of labour among the staff of the school.

Table 1. Conceptions and constraints of leadership during the workshops period 1-3

	eL-team (Ws1)	eL-team (Ws2)	eL-team (Ws3)
Tools	Tools are grounded in established practices of management and development projects	New strategies/tools are identified and adapted to emerging practices	A set of new tools are concretized and directed to redefined objects. The TPD model is adapted to local needs. Old tools are used in new social contexts
Rules	Rules are oriented towards the governing aspects of education and at the individual level	Rules are redefined for the support of new roles and teacher team work	Rules at a collective level of teacher team development are analyzed and redefined
Community	eL-team and the teacher staff as a whole are the primary collaborative units	New teacher work units are identified	A differentiated set of teacher team communities and their professional development needs are identified. The eL-team as a leadership community is redefined
Division of labour	The eL-team members have autonomous responsibilities but co-operate in implementing shared tasks	Restructuring of work tasks between the different school management teams, identification of work tasks for new teacher development teams	Rethinking and concretisation of task responsibilities between the eL-team, the principal and the new teacher development teams
Objects of activity	A multiple set of development objects operates (student assessment, portfolio assessment, ICT, student participation)	Objects of educational development are transformed to objects of leadership	eL-team activities are reorganized to support teacher development teams. The object of activity becomes a shared task of leadership

While a multiple set of objects of development and leadership are characterizing the activities in workshop phase 1, the conceptions of leadership become tighter and more focused upon strategies for professional teacher team development at the end in workshop period 3. Activities moved from the individual to the collective level of leadership, from the eL-team support of classroom improvement work to the support of developmental teacher teams focusing on shared objects of school development. The movement went on step-by-step reflecting tensions and contradictions between prevailing activity systems and new activities crossing into these systems. Gradually, the new leader team evolved as an autonomous organisational unit identifiable as a leadership community constantly interacting with other management teams and teacher professional communities. However, the object of leadership as an activity was still in flux at the end of the DWR process.

Tools in transformative practices

While the object of leadership was scrutinized and restructured during the DWR process a differentiated set of technologies and conceptual tools were operating. It is evident from the observation data that the *Shared Space* wiki technology, being constructed for serving the analytical aspects of the school development work, did not work as any vital and integrating tool for design and analysis. The eL-team members did not use this virtual space either to store or analyse project plans or practice descriptions. However, during the DWR process the underlying conceptual framework of the technology (the TPD-model) gradually becomes a social tool for discussion of their work practices. In contrast to this, the VideoPaper technology come to play a far more important role as a “mirror” and discussion tool for the team and teaching practices. The TPD-model was an integrated part also of this web-based

document structure (cf. Hauge & Norenes, 2009a; Hauge & Norenes, 2009b). In general, local tools for design and management of practices were preferred. The Learning Management System (Fronter), the institutional virtual environment, played a major role in everyday work of the eL-team, and supplied the team with basic management functions. Table 2 gives a general overview of prevailing patterns of practices focusing on technology characteristics, their use applications and experiences based on observations over time.

Table 2. Technology use and eL-team practices

Use characteristics	SSP-Wiki	VideoPaper	Fronter
Content features	Participants may store written information and media resources in html format, discuss, reflect and trace analytical work on given or open assignments. The content structure is flat and network aligned. The space is open for shared writing across groups and linking resources together.	Is designed to store local video recordings, pictures and written text in html format. Participants may use the tool interactively to reflect on resources by discussions online or social. Open for writing and editing content elements by group access. Content needs to be prepared and designed in-before hand by the participants. Require long-term planning.	The LMS is designed to serve multiple purposes in management of teaching and institutional information processes. The content structure is hierarchical. Is widely used for producing, storing and sharing of local information. Editing features are restricted aligned to group structures and authority patterns.
Application	Access was restricted to the users in the eL-team/DWR project. Was applied by the researchers to show main project elements and stimulate systematic use of theory, descriptions of local practices and design implementation. SSP served as a platform for shared project information.	Access was restricted to the users in the eL-team/DWR project. Was applied in workshops to show video recordings of teaching/team work, stimulate group discussions and reflections about practices.	Fronter is an integrated part of the institutional management infrastructure. The eL-team used it regularly as a shared platform for document storing and development, planning and sharing of information across user groups.
Experiences	SSP content elements were created as part of the social process of the project, but was systematized and organized by the researchers. The EL-team members did not actively create the digital resources themselves. SSP was not experienced as a useful tool in everyday work.	The content elements was designed and created in collaboration with teachers and eL-team members, but they had to be systematized and organized by the researchers. The integrated online and social use of the resources, as part of the workshops, engaged the P-team in joint inquiry-oriented discussions of leadership practices.	Fronter was an integrated part of everyday practice in the eL-team. Many Fronter elements served as routine practices.

This table shows distinct differences between the features of the SSP-wiki platform and the Fronter system. The systems were designed for different purposes and served different functions regarding the knowledge management work in the leader team. While Fronter was serving the daily routines of sharing and producing information, SSP-wiki was constructed to handle analytical functions directed to school and leadership development. The reluctances in using the SSP platform by the eL-team may be explained in different ways, however, during the DWR process and a follow-up meeting (February 2009) the team openly expressed that

the wiki platform did not fit their daily concerns and practices. The following discussion in workshop 2 illustrate the attitudes:

- R: Everything has to be efficient. All the work has to be finished here and now. Very little has to be delivered afterwards (the meeting).
- E: You (the researchers) have experienced that to reflect and then go into and write in the wiki, this is not functioning very well.
- S: That we have learnt from the actual experience (cf. the case study work after workshop 1).
- Researcher 1: Since you are using Fronter very much, to what extent do you want to use this as a storing system for what is happening in the teacher teamwork? (... eL-team talk about use of Fronter)
- R: Experiences are telling that it is difficult to go in and reflect on these things afterwards.
- E: May be we should suggest a discussion forum?
- R: And then it has to be some theory in there. Simple relevant theory connected to the work field.
- S: That would mean some demands upon us. What theory should it be?

Surely, in this discussion the team is very much concerned about use of time, to be efficient, to deliver things directly, and that they do not have time to dwell and reflect over things. Fronter seems to fit well into such a work culture, but the team is at the same time open for more advanced use of the technology – to a certain point. Discussion forums or places for theory accumulation are part of their concept, but such work has to be useful and efficient. The discussion excerpt illustrates the difficulties met in implementing the SSP tool, which laid down an alternative approach to analysing and constructing knowledge for school development focusing on shared practices of reflection. The wiki platform's functionalities seems too contradictory compared to the prevailing practices in the eL-team.

While the SSP usage seemed to be out of range for the leader team, the VideoPaper was far more accepted and utilized as an integrative tool for reflection on team practices and teaching. Productive talks about video recorded practices occurred several times in the workshops (cf. findings above), confirming that wishes and needs for reflections on and improvement of leadership practices were appreciated. However, the VideoPaper offered quite another practice of reflection than the wiki platform, by connecting practices to video film episodes recorded and edited by the researchers. The wiki platform required written cases or documents prepared by the team leaders themselves. The division of labour and the workload of preparing the reflection documents in these two tools were different, and the reflection genres were also different. This may explain some of the differences in technology preferences and motives in the leader group. The VideoPaper was experienced to be time efficient by the leader team and it directed their attention quickly to the key aspect of leadership.

The SSP-wiki platform and the Videopaper technology played a dual function during the DWR process: They had important roles in supporting the initiation and framing of the research process, but then they moved in the background when confronted with the overwhelming amounts of everyday problem-solving and decision-making tasks in the leader team. However, during the work process the TPD conceptual framework of these two imposed technologies gradually expanded into the DWR process. They contributed in the process of practice transformation as an analytical infrastructure.

The TPD technology integrated model for workplace development (Theory, Practice, Design model) was introduced to assist the systematizing of pedagogical thinking and design development in everyday work of the eL-team. During the workshops we observed changing patterns of conceptual tools use related to the three main components of the TPD model. Figure 3 illustrates the model functions pointing to tools use from a theoretical, practical and design-oriented perspective of social practices.



Figure 1 The TPD-model for workplace development

While discussions in workshop 1 was primarily directed to descriptions of prevailing assessment practices in the school, procedures and grounding ideas related to the national curriculum guidelines and strategies of school development, discussions in workshop 2 were broader and included a varied set of theoretical tools and means of work descriptions. The evolving design of a new teacher team structure for school development was an important vehicle for discussions of theoretical perspectives on existing practices and development designs in workshop 2. In workshop 3 the leader team becomes quite focused on tools and methods in teacher teamwork and the future work of distributing their responsibilities to new development teams of teachers. The conceptual change in model use is confirmed by a word frequency analysis of talks in the three workshops as summarized in table 3. The overview is based on the major and substantial parts of the discussions.

Table 3. Frequencies of leading concepts for workplace analysis

Main concept	Workshop 1	Workshop 2	Workshop 3
Assessment	84	93	15
Portfolio	50	36	44
Change/development	40	72	43
Leadership	4	51	11
Practice	41	70	45
Theory	0	1	29
Object	13	4	102
Team	11	46	12
Development team	0	88	96
Methods	0	7	14

Each of the words counted in table 3 comprises the core concept and a set of related concepts framing leading themes of actions by the leader group. In general, the frequency numbers confirm the changes described above about conceptual changes in leadership. However, behind these numbers we observe some conceptual features and tools usage:

Assessment: student assessment in different forms has a prevailing position in workshop 1 and 2, is connected to procedural practices and established design solutions, but is not elaborated in relation to new theories (is connected to curriculum aims).

Portfolio: has a leading position for experiential learning in the leader team during all workshops, is part of a dynamic development work design, comprises a set of practice descriptions, is pushing existing theoretical conceptions of assessment and learning.

Leadership: has an important position in workshop 2 in connecting actions to new teacher team development and the discussions of object of development.

Practice: is being more and more specified during the workshops and aligned to certain practices, e.g. team practices, portfolio assessment practices. Demands for practice descriptions are growing.

Theory: is not very much used in workshop 1 and 2, but becomes more sophisticated in workshop 3 and aligned to what theories should govern the development and leadership work.

Object: becomes an important discussion theme in workshop 3, evolving as a tool for analysis of activities and design development, and theoretical tools considerations.

Team: has an important function in workshop 2 directing discussions to leadership roles and distribution, is first of all connected to the eL-team activities.

Development team: is a major artefact in workshop 2 and 3, reflects new leadership ideas and structures, and new tools for descriptions and design of practices.

Methods: has a growing position from workshop 2 to 3 aligned to requirements for teacher team development and specified tools for support, monitoring and analysis, but is little connected to theoretical considerations.

The list shows that a variety of conceptual tools are at work in the DWR process. At the beginning tools use is primarily aligned to procedural and design-oriented activities, however, gradually we observe how the eL-team utilizes a broader set of tools connected to the TPD model. The TPD model and the technologies supporting the model seem to function as mediating means for the conceptual changes that primarily are worked out in the social setting and not in the virtual environments.

Summing up - educational leadership in change

Leadership has transformed by a new dynamic new leader team in the actual school. The principal, who initiated the change, moved parts of his authority on educational matters into an intermediate group between himself and the teachers focusing on joint efforts improving teaching and learning in his school. This group of former team leaders and department heads, who knew their colleagues very well, took a leading position in systematizing and nurturing school development work in 2007-2008.

Educational leadership as an object of activity evolved through two main phases during the Developmental Work Research process: It emerged from a position of high expectations towards educational leadership for the improvement of classroom practices, to a position of leadership working with and through teacher professional development at a collective level. For a half of the time during the project the object of leadership was related to activities supporting individual teachers or pilot group of teachers in improving their classroom practices. The development practices were then focused on student assessment. The object of activity transformed through a break down period in the project where tools and activities were questioned being exposed for perspectives on institutional leadership. Leadership for the improvement of classroom practices were confronted with institutional macro perspectives and a long-term investment in leadership for teacher team development.

The concept and practices of leadership seem to change because of a leader team who never stopped wandering about goals, tools and activities and their leadership roles. The DWR process was in itself a mediating means for the transformation of practices. The external technologies in use played a dual role: They legitimized the interventions and the conceptual framework of change, but the tools did not function as any main vehicles for the transformations. However, during the interventions we observe how specific conceptual tools belonging to the technologies are appreciated and adapted to local practices. Further, we observe that the external tools (SSP-wiki and VideoPaper) did not succeed to be implemented in everyday practices of the leader team, whereas the local Learning Management System (Fronter) seemed to cover prevailing needs for documentation and shared information. None of the technology practices did compete with the fast-running social interactions of the leader team in re-constructing conceptions and practices of leadership.

Leadership practices in the actual school were changing both temporally and socio-spatial (cf. Engeström, Puonti & Seppänen, 2003). Data shows how the object of activity are moving in time from a teacher oriented perspective of classroom work to an institutional perspective on how teachers should be supported for improving their practices. At the same time we witness how the object move in institutional spaces, i.e. from individual to collective spaces of practice. The changes happened along with a continuous discussion about means and ends in the project facilitated by the three-step workshop cycle and tools brought in by researchers and the school participants. The study tells a story of the complexities in changing objects of activity and basic activity structures.

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3.3 Knowledge creation and production processes in transforming social practice.

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“Knowledge creation and production processes in transforming social practice (Ahus case)” (case 10.3) is a longitudinal case study. The context of the study is a hospital that plan to utilize technologies as much as possible; target and change their work processes to ensure comparable care and treatment trajectories, and qualify for ISO certification. We have investigated knowledge creation and practice transformation following re-design from provider centric models of care to work processes guided by a patient centric vision, supported by practice guidelines. When we focus on their processes to consolidate and standardize repositories of nursing procedures we gain insight into processes to develop a comprehensive knowledge infrastructure. Utilizing and mobilizing resources to communicate applicability of the work description for their work processes helps understand processes when practitioners are making the standards relevant for their competent practice, and a Knowledge Management infrastructure play out to support transformation of their practice. We have also studied design of a web- based learning environments for on the job training and competence development in nursing. Our findings give some insight into how content is represented and how the tool is perceived and utilized. This report draws on different presentations and publications from the case.

Introduction

The hospital’s new tools include a comprehensive knowledge management infrastructure with multiple repositories, one of them being work descriptions for nursing, and interactive, web-based learning environments. As a case study for KP-Lab we are exploring transformation processes to historically new practices materializing in the re-designed work processes and patient centric practice vision supported by this ICT-based knowledge infrastructure. The transformation processes take place in hybrid spaces (virtual and f2f) and are mediated by available and emerging artefact structures; integrated, tailored and/or expanded tools. To complement the efforts to streamline work processes and standardize work descriptions, they also change the approach to introduction processes and programs for learning at work in the hospital by introducing eLearning solutions. Our investigation focuses on the following

- What are knowledge creation processes and production from consolidation, use, modification and re-use of standardized work descriptions – the tool – as
 - part of the ICT-based knowledge management infrastructure?
 - integrated component in the Electronic patient record system?
 - shared artefact mediating professional development, staff mobility (boundary crossing), and new social practice?
- What kinds of resources do professional mobilize and how they position themselves as individuals and representatives of local practices in knowledge creation processes exploiting the consolidated work descriptions and reflect on their practice?
- How do professionals reason and negotiate in processes to develop pedagogical design and content in a web-based learning environment related to the comprehensive ICT-based knowledge infrastructure and the transforming knowledge practice?
- How are affordances of a web-based learning environment articulated in collaborative talk and utilized in instructional design?

So far 340 professionals have been involved in different part of the study. In this section we will summarize findings from the collected material as the insight we have so far.

Research design and methods

This is a longitudinal, multi-level case study where we trace ongoing processes of transformation as the intervention unfolds. This case study offer in-depth insight to knowledge production processes and knowledge accumulation during practice transformation enabled by

emerging knowledge artefact structures. For KP-Lab, this adds analytic understanding to ‘triological learning’ because triologicality or triadic structures requires historical, longitudinal analysis of evolving practices. Our study requires an extended ‘unit of analysis’ that capture production of complex knowledge objects, and explore use and re-use of ICT-based knowledge artefact in knowledge creation processes.

We investigate evolving comprehensive knowledge management infrastructure, ICT tools’ potentialities for knowledge creation and knowledge artefact use and re-use. Our empirical material includes 1) video and audio taped observation from consolidation meeting, 2) stakeholder interviews, 3) document review and field notes, and 4) data about repositories’ use, and are mostly qualitative in nature (Silverman, 2005). Our analysis draws on interaction analysis (Jordan & Henderson, 1995). We focus specifically on the participants’ interpretation, use, modification, and integration of tools in local practice, and how different initiatives in sum contributes to transformation of knowledge practices. So far we have been restricted to study 3rd party tools to understand how professionals may appropriate such infrastructures. We also have plans to use KP-Lab tools for data collection and analytic purposes.

Major findings

In this section we will first report empirical findings from the investigation of consolidation, customization and first experiences with the work descriptions in the knowledge management infrastructure. In the second part we will report empirical findings from the local design/customization and piloting of the interactive, web-based learning environment.

Knowledge management infrastructure with work descriptions

The processes relate to create an extensive Electronic Quality System (EQS), which consists of different handbooks, rules and regulations, certification and learning/introduction programs, and work-process descriptions. A new technology implemented in their EQS is a repository of standardized work descriptions called Practical Procedures for the nursing Service (PPS). We will discuss one example of how they worked to consolidate the work descriptions and how nurses reported on use of the PPS-procedures.

We have observed development and expansion following consolidation and customization of local, in-house work descriptions and work descriptions in a standardized repository, PPS. PPS is a repository with standardized work descriptions that are used in skills training labs for nursing students but also available in community health and hospitals. Currently PPS contains 267 standardized, clinical procedures performed by nurses. Each PPS procedure has a step-by-step text description, explaining “how to do”, “devices/equipment” and “observations”, complemented by animations, illustrations, photos or video. The local in-house pool of nursing procedures were paper-based and there were up to 8 versions describing the same task, some procedures had local scribbled additions, and the procedure itself could be more than 10 years old. Work descriptions embody accumulated experiences and knowledge, and have a formalized and directive role in nurses’ work.

The consolidated PPS is one of the repositories accessible in the EQS. In addition to give direction for the work, part of this solution is to use the work descriptions for the documentation processes required in the EPR. In addition, the PPS-based work descriptions can be accessed in the nursing documentation in the hospital’s Electronic Patient Record (EPR). The EPR is a core information system supporting everyday, clinical work in a hospital. These work descriptions are accessible for different purposes, and distributed throughout the hospital and applicable across professions (the procedures are not only restricted to nurses) and hospital specific units. Procedures may be hyper-linked with the patients’ treatment plans and accessed directly through them. Any deviations from the procedures should be reported.

As part of the implementation of the PPS, the institution organized a comprehensive process to consolidate the repository. Working groups reviewed the work descriptions about a clinical domain, one by one, in a very systematic way to consolidate work descriptions from two sources; the hospital's existing pool of procedures and the PPS system's procedures. In addition national regulations and handbooks are used in the negotiation. Also the group members consult with other colleagues; they take the discussions out of the meeting's context, and consult physicians and the local research department about the content of the procedures. Suggestions made by the groups are summarized before additional review in a reference group. The reference group has representatives from all the hospital's clinical departments. They meet to review and ensure consistency across different work descriptions. The final outcome of these negotiation activities is a consensus text marked in a 'red space' on top of each procedure. This 'red space' contains a hospital specific note to the procedure.

The work descriptions exemplify accumulated experience expressed in local work description in use in the institution and standardized, more general work descriptions collected in PPS. The practitioners' efforts to streamline work descriptions for nursing can be seen as examples in knowledge creation, and we will illustrate interactions and resources drawn on in the observed negotiations. Consolidating the work descriptions is their 'shared object of activity' that the productive interactions and knowledge creation relates to. Standards have to be flexible enough to be used in the different departments at the hospital and robust enough to keep its status as evidence-based procedures. The negotiation of the standards is not only about the tools itself, but also a negotiation of different knowledge domains (Moen & Nes, 2008, submitted; Nes & Moen, submitted). This allows us to discuss how the participants relate differently to the ongoing efforts to establish best practice and also a snapshot to how the different practices have emerged in different departments and units in the hospital.

Negotiations and consolidation of the work descriptions

Drawing from the extensive, participatory observation of their consolidations we have chosen one example from the video recording material. In the empirical material we found that their negotiations culminated in the "*red space*" text, and we have analysed the resources they mobilized to reach consensus about this text. Across the material we can summarize that the "*red space*" communicates status, as

- (a) approved work description (192 of 267 procedures),
- (b) conditioned approval with links to alternative or addition information in EQS (49 of 267 procedures),
- (c) disapproved work description (26 of 267 procedures).

To point out what lead to the '*red space*' text, we systematized the resources participants introduced when consolidating the repositories. Findings show interaction of (a) *explicit knowledge*, as reference to legislation, standards, or published papers and books, (b) *collective expertise* reflecting more systemic practical knowing, and (c) *personal experiences*, presented as how to do the work or extreme cases related to the described work (Moen & Nes, 2008). A consolidated procedure looks like this;

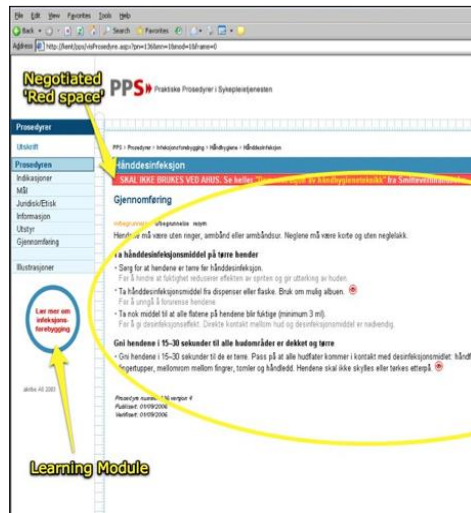


Figure 1: consolidated PPS procedure

We have selected a situation where tensions between the PPS procedures and local practice at the hospital surface. We analyze their talk as interaction (Jordan & Henderson, 1995). In the selected episode (also an example of a productive interactions for knowledge creation (see D8.4)), a working group’s negotiations where the participants mobilize different knowledge and experiences as resources in their talk to deepen the understanding of the variety and consolidate one version about procedures for “Stain disinfection”. The participants; Nurse1, Nurse2, Nurse3 and Group leader1 and Group Leader2, are local experts and represent their departments’ perspectives. Nurse1 is from the infection department, Nurse2 and Nurse3 are from the operating theatre, and Group leader1 and Group leader2 are from the hospital’s competence department. They contribute perspectives based on their accumulated, everyday practice, and interpretations of guidelines and handbooks as they consolidate PPS procedures and versions of in-house procedures. The starting point for the chosen example is differences in the hospital’s practice and the explained practice in PPS description.

As this particular episode starts, they have discussed for almost 20 minutes and Nurse1 summarized that PPS says, “wash first, then disinfect”. According to her this is contrary to the national guideline for hygiene and infection prevention and their local procedure; both saying “disinfect first, then wash”. Instead of closure as suggested by Nurse1, their interactions take new turns, starting as discussions between Nurse1 and Group leader2,

2. **Nurse1:** ...the case is postponed and then [he he], but anyway... our opinion about the procedure is still the same.
3. **Group leader2:** yes ...
4. **Nurse1:** The procedure is not valid because our policy is “disinfect first then wash”we [infection prevention dept] cannot approve a procedure that expose, both the hospital environment and the staff, to infected material.
5. **Group leader2:** ... if it’s right, what it says here [in PPS]? [that] you actually can wipe off ... in the case of massive amounts of waste ... in fact you can soak up first and disinfect afterwards... if they [PPS] say that, you diverge....

Although Nurse1 maintains that the procedure for stain disinfection in the PPS is wrong, requiring a new, local procedure for stain disinfection, their negotiation opens up again. In passage 5, Nurse1 is ‘forced’ into further interaction when Groupleader2 introduces experienced deviation in special circumstances. They continue to negotiate about stain disinfection – as “disinfect first, then wash” or “wash first, then disinfect”. Nurse1 maintains, “disinfect first, then wash”, justified by objectives for protection and prevention and a practice complying with national standards and regulations (passage 4). In response, Group leader2 points out that according to her reading of PPS, “wash first, then disinfect” is acceptable if

there is massive amount of waste, and suggest that this is a question of judgment as they deal with the problem in particular situations (passage 5).

Their discussion continues and several examples of special circumstances and local situations are brought into the negotiations. The discussion continues

6. **Nurse1:** Then... no, then we have to define what is massive amounts of cleaning...massive amount of waste?
7. **Group leader2:** Yes [hesitating]
8. **Nurse1:** And massive amount of waste is not a little bloodstain on the floor.
9. **Group leader2:** Yes [skeptical]
10. **Nurse1:** so...
11. **Nurse2:** It's a difference though ... if you're in a situation with infection in the operating theater, in a way, ... you act a little different than if you have an ordinary spot of bloodstain.

When Nurse1 asks for a definition of “massive amounts of waste” their discussion takes a new turn. In passage 6, Nurse1 suggest that ‘massive amounts of waste’ should be defined, since it is certainly not and should not be understood as “little bloodstain on the floor”. Nurse2 introduce examples from her local setting where they often solve everyday problems according to “wash first, then disinfect” (passage 11). She introduce examples of accumulated expertise, explaining that they ‘act a little different’ in her unit, referencing extreme cases in ‘real life’ when they do not handle ‘an ordinary spot of bloodstain’. These real-life problems and local solutions are not challenged the others.

12. **Group leader2:** mmm [confirming]
13. **Nurse2:** ... because you... then you have gloves on and you put it in ‘risk-garbage’ and that’s...
14. **Nurse1:** But you shouldn’t do it anyway...
15. **Nurse2:** But I’m thinking if you have a major puddle, then it [disinfecting agent - VIRKON] will never go through all the infected material
16. **Nurse1:** Yes, well that depends how much... [unclear]
17. **Nurse2:** ...yes that’s how I see it. That’s what I’m thinking.., logically it’s less risk for spreading it as long as you put it in waste-garbage... [because] that’s what you do.

Here, in passage 12 to 17, the negotiations focus around local examples of how particular instances requiring ‘stain disinfection’ has been handled in the past. Local practice and personal experience are used as examples when universal applicability of a work description is debated, and examplfies explanations where the entire department gets a collective voice difficult to ignore.

Their productive interaction relates to sorting out that standardized work descriptions are prescriptive, to be followed, and at the same time the practitioners’ should modify if any particular situations require deviations from the descriptions.

29. **Nurse2:** ... just thinking ... if there’s a lot, ... a whole mound of, like a puddle, which is the case in our department sometimes.
30. **Nurse1:** Then you have to consider doing both. That you spray disinfec...
31. **Nurse2:** ... first and then once more? (unclear)

The productive interactions for knowledge creation plays out between Nurse1 who argues for a general and universal position emphasizing no deviation from these standards, and Nurse2 emphasizing local circumstances and situational aspects in the consideration. In the interaction we see a shift when the two nurses makes a ‘gap closing’ with reference to their different views. Acknowledging Nurse2’s contribution to the negotiation, Nurse1 opens for situated judgments and interpretation of a work description, acknowledging that some situations require untying the standards.

36. **Nurse1:** ...yes then you spray again... then I think we are talking about massive amount of waste... but I’ll check with them [national guidelines], and get a definition of massive amount of waste and what they actually are meaning.
37. **Group leader2:** Yes, because the point of this is that everything ... just... things may not be as clear, as you first thought, right

In passage 36, they reach a temporary solution; Nurse1 will check out what constitute “massive amounts of waste”, consulting National Guidelines, experienced peers in the local research department, and clinical departments. When the group reconvenes, Nurse1 explains what the department she represents has concluded in her narrative;

“ ... then *stain disinfection*, eh, ... we had some very heated discussions, related to what is really said from the Norwegian Medicines Agency we contacted with them, and I do not think they really know what they have written either we contacted the National hospital and several other hospitals ... in addition we checked CDC [Center for Disease Control] and John Hopkins and what is available from the Norwegian Institute of Public Health and there are only suggested recommendations and no requirements, but they are also quite vague. we have discussed a lot back and forth in our team of experts [specialists in infectious diseases, epidemiology, public health nurse] – we go for one universal, non-ambiguous procedure that makes everyone do it the same way, whether the stain is spilled on a wall or on the floor, on some of the equipment or ... whatever it is. The conclusion we reached, ... it is really disinfection of everything, ja. ... the PPS procedures “disinfection” and “stain disinfection” says nothing about the protection, for the to personnel that should remove, what you actually should do with massive contamination. So our conclusion is that the PPS procedures are replaced with our alternative – we just need to find a more appropriate name – disinfection of ... -

The group endorses a conclusion suggesting that a standardized procedure should be a universal, non-ambiguous description that ensures the same practice. Their interactions illustrate local knowledge creation, but the outcome of discussion and recommendation by a team of experts outside this working group is privileged.

This example of negotiations rooted in different awareness about a certain aspect of their work; interpretation and application of principles for stain disinfection. The contrary principles “wash first, then disinfect” or “disinfect first, then wash” lead to lengthy discussion and negotiation. The local experts participating in the interaction articulate different perspectives. They reach an agreement that recognizes a certain room for interpretation of application of the guidelines, i.e., adjustments depending on the amount of waste. They articulate different perspectives. Their knowledge creation culminate as gap closing when they sort out that although standardized work descriptions are prescriptive, to be followed, but there might be that require deviations from the description. The “red text” for this work description says that the work description should not be used. They make reference to a new, alternative work description. In this new description, they added the dimension “protection of personnel”, and this reflects an example of created knowledge. The new procedure endorses the conclusion that a standardized procedure should be a universal, non-ambiguous description that ensures the same practice.

Use of the knowledge infrastructure with work descriptions

To monitor nurses’ self reported use and experiences of utility of components in the emerging knowledge management infrastructure EQS, the utilization of PPS has been elicited in a survey (Bøe, Standal, & Sundstrøm, 2008). The survey findings are especially important and interesting for KP-Lab as they provide baseline information to this case study of knowledge practices in Workplaces. Bøe et al. (2008) discuss PPS as a system providing easy and organized access to updated knowledge and accumulated experiences (indirect decision support), and in some instances offer very specific advice and guidance for decision making (direct decision support). The questionnaire focused on perceived information- and system quality of the PPS system, and how these factors affect use and experiences of usefulness. A sample of 346 RNs and enrolled nurses met our inclusion criteria; RN/LPN in operative service, working more than 50% of a FTE, work different shifts. 245 respondents completed the survey, representing an overall 71% response rate.

Findings from the survey show that most of the respondents use PPS and want to use PPS (80%, n=245). The reported usefulness of PPS related especially to availability of new

knowledge, increased safety when performing procedures and improved professional quality of the care provided to patients.

Table 1; self-report on usefulness and value of PPS

Usefulness and value of PPS (n=195)	Frequency	%
Time savings	25	12,8
Improved quality of provided patient care	76	39
Easier to create treatment plans	55	28,2
I feel more secure to do the work when the work descriptions are available	109	55,9
Improved professional quality of documentation in the EPR	51	26,1
Work descriptions are easier to find than before	57	29,2
Work descriptions are easier to understand than before	28	14,4
Work is easier to do with the work descriptions	34	17,4
I have gained professional knowledge from PPS	112	57,4

The information quality in PPS was evaluated to be good, regardless of frequency of use. In general, PPS was used weekly or monthly, only very few respondents consult PPS daily. However, a large part of the sample (59,2%, n=240) state that they would choose to ask an experienced colleague rather than look up and use PPS when they were about to perform a task they were unfamiliar with.

If they did not follow the PPS's descriptions their reasons can be summarized as

“the procedure is too comprehensive, detailed and cumbersome”,

“it is too time-consuming if we should follow the procedure”

“the procedure deviated from our traditional practice”.

Some of the respondents reported that they had not started to use PPS yet because they found the PPS-user interface poor; it took them too long to find the right information or what they were looking for. The respondents that reported good computer skills used PPS more frequent, and they did not share the concerns about the user-interface. A lot of the respondents report lack of available computer among reasons for not being able to access and use PPS when they need it (Bøe, et al., 2008).

Introducing knowledge resources and implement new IT-systems in health care requires systems of high quality, in terms of the available information and knowledge, and the system's functionalities and services. This includes 'ease of use' of the system in terms usability and access to the resources at he point of need. In addition the content of the system should provide updated, high quality knowledge and information that easily can be made relevant for situations at hand. In addition, findings from this study point to age, general computer skills and informatics experience as factors that differentiate the survey respondents with regard to use of PPS. The organization can still focus on improving the nursing staffs' general IT skills and develop strategies to encourage use, to fully capitalize on the introduction of PPS and the comprehensive knowledge management infrastructure (EQS) to meet goals of practice transformations. Allowing staff time and opportunities to develop and practice computer skills seems to be a prerequisite before they can start to appropriate the new tools and resources in the knowledge infrastructure.

Exploring ease-of-use of a system, content evolution and creation, and user's competencies are important for tool-mediated knowledge creation and production processes, and is likely to influence on-going transformations. The material from this survey will be used for future comparison – benchmarking-, when the survey is repeated. This will provide further insight to the use of the available resources and the role of tools in an on-going practice transformation.

Use of the work descriptions in the EPR

In addition to participatory observation of the consolidation of the different version of the work descriptions we explored how the nurses started to use the new tool – consolidated work descriptions – as part of representation of the nursing care in the EPR. The hospital's EPR is the core information system supporting everyday, clinical work in a hospital and accumulating the collective history of patient's care and treatment. We can report on the first experiences with integrating PPS procedures in the EPR care plan, as Horvati (2008) explored how the nurses used PPS in the EPR. The integrated PPS-EPR aims specifically to improve quality and efficiency of the accumulating documentation by the clinical procedures. The empirical material is collected in interviews and observations. The focus is the users' use of and perceptions of integration of the PPS and the EPR. To facilitate active use of the comprehensive knowledge management infrastructure and improve quality and efficiency of the clinical documentation the clinical procedures in PPS are available in the EPR. We took snapshots of how they used the PPS in their representation of nursing care, as shown below:

	Documentation - PPS templates	Documentation - templates	Assessed records
Sept. '07	27 (.35)	55	73
Dec. '07	60 (.50)	82	121
Mar. '08	53 (.40)	109	134
May '08	62 (.35)	111	170

Figure 2: snapshot of PPS used in the EPR

In the interviews, we also saw some differences according to clinical experience and the resources they consult, and the interviewees pointed out

.. the procedures I learned here at the ward, I don't look up in PPS, so I really don't know how they are described, but I would guess that they are pretty much alike what I have learned here at the ward, because here has people been working for many, many years (#6)

.. I have been on leave for a longer period, and looked up some procedures in PPS, and I find a description which is not out of date, .. I feel updated, and it is very useful, like a brush up on my knowledge (#2)

... we put it in the care plan, we do, but doesn't mean that it is active use, does it? It's more like formality. And you do what you are used to do anyway (#1)

One can argue that this does not mean that nurses evaluate their actual *practice of patient care*, they can only evaluate how clever they are in *documenting* the practice. As such the components in the knowledge management infrastructure indirectly contribute towards 'best practice' (Horvati & Moen, 2008). In this survey, Bøe et al. (2008) found that the actual use of procedures as part of the clinical documentation (i.e., use of PPS link) varied according to self-reported IT-competencies, felt mastery of computerized aspects of their work and experiences with computerized clinical documentation. The organized introduction to PPS and PPS influenced their use of EPR-PPS link in the clinical documentation, and not PPS per se.

These findings points out though that the integration is functional to support the work. To fully capitalize on this knowledge infrastructure's affordances and knowledge creation potentialities, the (re)-organizing of work processes seems crucial to better understand when, how, why and for what they use the new tool; the integrated PPS-EPR. In addition, further studies ie necessary to explore how this adds to the already existing complex knowledge infrastructure at the hospital. WE also believe it is crucial that the organization as such, managers in charge and users reflect on the existing affordances in the knowledge infrastructure as this contribute to co-evolution of the work, the accumulation of documentation in the EPR and the infrastructure (Horvati, 2008). The idea of integrating a

knowledge repository in the core information system of health care workers, and thereby their core work processes adds to the notion of understanding technology-mediated knowledge practices in knowledge intensive organizations.

Interactive, web-based learning environments

To illustrate how the new knowledge management infrastructure play out, we also followed the process to design and start to use one of the components in the web-based, learning environment. Our empirical material includes video recordings, interviews and analysis of the available artefacts. This part of our study follows activities to use new work descriptions and ideas about best practice as scop-watch in a cardiac unit and adapt a learning management system to a purpose specific web-based learning environment. A scop-watch works in the cardiac unit, and we will first describe the setting, the work and the traditional introduction approach.

A cardiac unit is a technology rich, knowledge intense work environment. The tool setup includes a central unit - “the hub” which is comparable to a coordination centre or dashboard – that connects to and collect information from a number of bedside monitors and mobile units (telemetry). The figure below illustrates this:

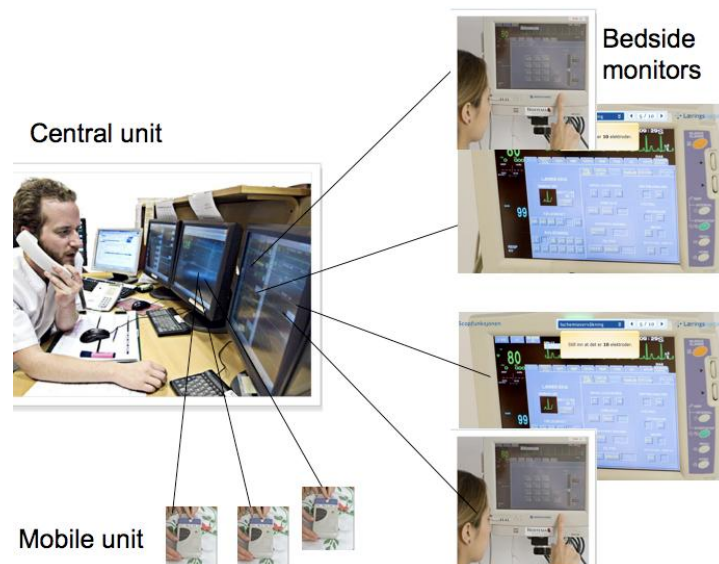


Figure 3: Tool set-up in the Cardiac unit

The scop essentially is a sophisticated oscilloscope. On the screen the graphic heart rhythm is displayed. For each generation of equipments, the functionality of the scop; central unit, bedside monitors and mobile units, has developed and expanded. The objective is to detect variations in a patients’ heart rhythm, and contribute to early intervention or prevention of premature death from a heart condition. The goal and overall purpose of monitoring is to reduce “time to treatment” by early detection, prevention, and/or precise diagnostic process for best treatment choice. Currently, alarm and memory functions as well as opportunities to store and trend the monitored data, collect up to 12 channels of the ECG allowing for monitoring of rhythm, diagnostic work of ischemia⁴ and complex arrhythmias are commonplace. To fully benefit from this increasingly complex and sophisticated equipment for heart rhythm monitoring and ischemia surveillance it is important to utilize the available functions.

⁴ occur when oxygen supply to the heart is constrained

The amount and type of information coming to the central from the bedside monitors allows for interpretation of heart rhythm and possible ischemia, and the information from mobile units support interpretation of heart rhythm only. For efficient and proper monitoring, the set up on the bedside monitors as well as the mobile units are important, and overseeing this is also part of the scop-watch responsibility. In addition the central unit has tools for receiving pre-hospital ECG (not shown above), and the scop-watch organize the process for MD's evaluation and initiate decisions about patient treatment based on the received ECG of a patient underway to hospital.

As scop-watch the nurse oversees the monitoring technology from the Central Unit, and observe and interpret the heart rhythms of patients under diagnostic, cardiac surveillance to contribute to best possible patient outcomes. The nurse who perform these tasks should know and master the required procedures and routines, including communicating with nurses in other units, handling the equipment, procedures and routines for monitoring, variations and deviations, early interventions, alarms, code etc.. The scop-watch has specialized knowledge and oversees the monitoring technology to observe and interpret the heart rhythms of patients under diagnostic, cardiac surveillance. The scop-watch has specialized knowledge about heath rhythms, cardiac monitoring and care and treatment of cardiac patients.

The cardiac unit joined the institutional efforts to standardize work descriptions and started with the work as scop-watch. When design of the web-based learning environment started they had started descriptions of a) tasks and responsibilities as scop-watch, b) principles for monitoring in the cardiac unit, c) telemetry monitoring of patient in other unit, d) monitoring patients post PCI (Percutaneous Coronary Intervention), and e) pre-hospital ECG. Part of the challenge was that the available functionalities was not used to its full potential, As a consequence, there were surveillance of heart rhythm, but low utilization of functionalities for ischemia monitoring, imprecise and actually a lot of false alarms, and low utilization of stored vital signs like BT (blood pressure) pulse, ST-segment (the part of the heart complex showing possible ischemia) and so forth. Therefore, the upcoming situation with increased number of patients (workload and responsibility) created opportunities to revisit the practice, and focus on calibration, alarm settings and use of retrieved information for trending, especially of the ST-segment that was at the centre of ischemia monitoring.

There are several sources or artefacts created to explain this specialty work. They include work descriptions, booklet - how to solve common problems with the scop (a sort of FAQ) and posted information about selected aspect of the work.

The most important work descriptions ones are;

- a) scop watch in the cardiology unit,
- b) monitoring principles in the cardiology unit,
- c) telemetry monitoring of patient in other unit,
- d) monitoring of patients post PCI (Percutaneous Coronary Intervention or coronary angioplasty)
- e) handling pre-hospital ECG (in the example)

These descriptions follow the template developed for EQS (the knowledge management infrastructure), and adhere to the hospital's outlined process for creation, peer-review and authorization of work descriptions.



Figure 4: Facsimile of work description, example pre-hospital ECG

In addition to the work descriptions, one of the professional development nurses developed the “pekebok”. “Pekebok” is a booklet with concrete examples about how to operate core

functions of the scop central unit or the bedside monitor. The picture below exemplifies by pictures and explanatory text how to retrieve an ECG printout from the bedside monitor.

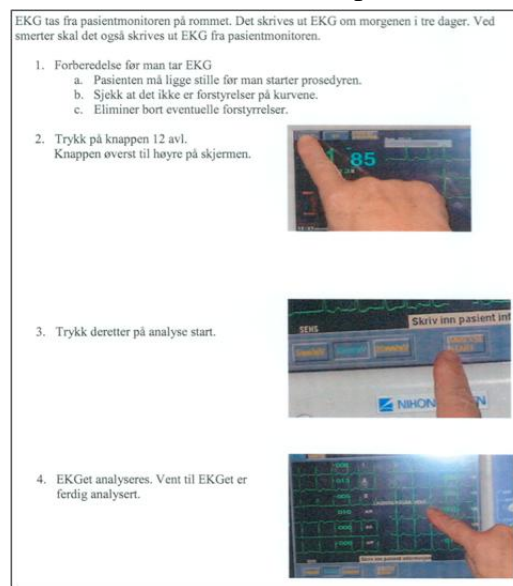


Figure 4: Facsimile, how to print patient's ECG from bedside monitor (10 channel)

In addition to explanations of how to use the equipment for specific functions, the “pekebok” also include information and instructions of how to solve common problems with this equipment for heart rhythm monitoring. In addition there are hard copies – sheet of papers - with suggestions for explicit work descriptions about the available tool. These posted notes can address a pressing issue, be an initiative to provide information or invite to discussions.

Traditionally experienced nurses introduce new colleagues to “scop-watch” work on an individual basis, much like an apprentice approach where newcomers are gradually socialized to practice in this specialized, technology rich environment. The proficiency of knowledge, experience and skills is evaluated informally, and scop-watch work is carried out with much variability. The individual introduction had been complemented by a series of seminars about aspects of cardio-vascular monitoring. The following topics; 1) interpretation of normal heart rhythm, 2) arrhythmias, 3) advanced CPR (Cardio-Pulmonary Resuscitation), 4) practical introduction to the unit, and 5) formal explanations of scop-watch responsibilities, was covered. The interactive web-based learning resource target; replace and expand on current introduction to the topics 4) practical introduction to the unit, and 5) formal explanations of scop-watch responsibilities. This prepares for continuous observation of heart rhythms and explains the scop-watch function in more detail.

The objective of designing and implementing a web-based learning tool as part of the scaffolding of work as scop-watch is to make expertise development simpler and more effective and increase patient treatment quality. To design and implement the eLearning course health care professionals had access to a Learning Management System (LMS) and a Publishing system that operated as an add on to the LMS. Two standard solution tools were adapted for the local learning context. The LMS SmartLearn provides tools for implementation and administration of the courses, and a course catalogue where the individual user to sign up. The course consists of two modules: The first module is a conventional course containing subject content in the form of text, pictures, exercises and simulations of work flow and central procedures. The second module was a mandatory test that the nurses go through regularly to attain and maintain their ISO certification to perform this function. The publishing system, Mohive eLearning Publishing System (eLPS) was integrated as an add on into the LMS, providing interface for the course content. It is also an authoring tool for the

content construction process. The tool has a media repository for storing, grouping, searching, and manipulating content that will be used in the creation of e-learning courses. When uploading content into the media repository, Mohive automatically converts content into bandwidth-friendly formats. The authoring tool does not require in-depth technical skills and the users have access to a set of templates for creating content in the form of exercises including multiple choice, drag and drop, video, explore and many others. Authors can also easily create tests and question pools.

For local adaptation into this context, the available templates in the authoring tool did not meet all the requirements of the users developing the course. To compensate for this, simulations of workflow and procedures were created by flash technology. A consultant representing the supplier of the Learning Management System collaborated with them to develop the flash simulations. Two flash sequences were developed for the subject content module. Series of pictures from the work environment illustrated workflow. Text explanations guide the end users as they click their way through the procedure simulating how this would be done in real life settings. Two corresponding simulations without the illustrating text guidance, were added to the test module as exercises the end users must perform during the certification test.

Such functionalities for interactivity rest on the axis of simplicity (assignments as sequences of slides) and multiplicity (assignments with combinations, built up sequences and simulate processes). In addition to interactivity, there is support for multi-modality through extensive use of pictures, with hotspots to explore certain aspects and texts explanations in general. The web-tool is built as an authentic and familiar environment. There are extensive utilization of pictures from the unit, of colleagues carrying out certain types of work and of the different tools and how to use them. There are text, facsimiles of important documents and pictures, stand alone, with hot spots or built up as flash sequences, to simulate and demonstrate the work. Interactivity and multi-modality is actively built into the resource so the user deals with the subject matter in assignments ranging from simple exercises and rather complex, interactive sequences (Gauperaa, 2008). The collage of pictures below give some examples from the web-based learning resource. They have used different templates in the publishing system.

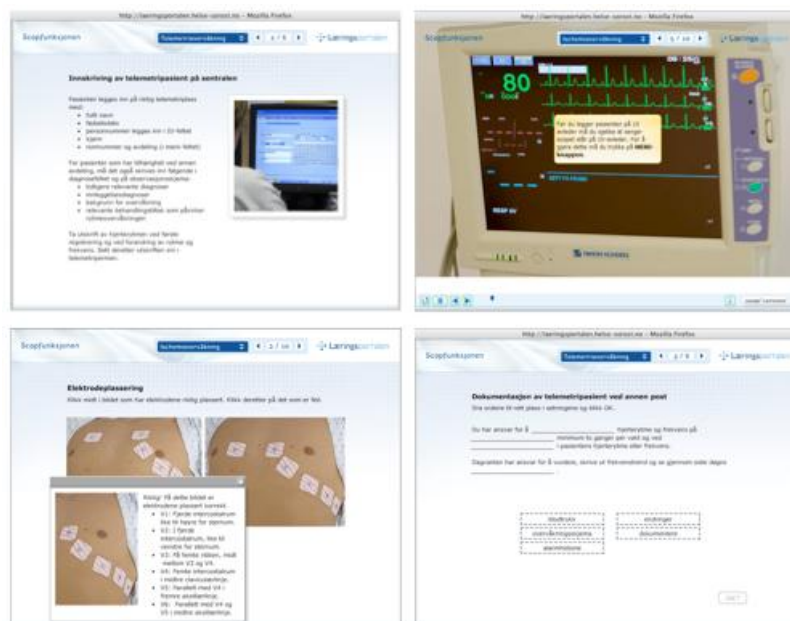


Figure 5: Examples from the web-based learning resource

As such the design of the resource led to an interactive solution resembling simulation qualities, and act as “a safe place to make mistakes” (Mohive, 2008). This points towards how the artefact provide for interactive training and “light” simulations as a way to train procedures (implement work descriptions) thorough interactions with the components prepared in the web-based learning resource.

Developing content for the web-based learning environment

The web-based learning environment has several modules to elaborate best practice as scop-watch and simulate use of the monitoring technology. Our empirical material so far includes video-recordings from the team of nurses designing this specific learning environment, analysis of the created web-based learning tool, and interviews with pilot users and later follow-up with one of the professional development nurses. To start elaborate findings from our material we will zoom in on one tension identified the empirical data, and how this is dealt with in the design process. We will also present pilot users’ feedback, and how use-experiences points towards transformation of practice and further use of the web-based learning environment.

The main resources in which the nurses relied on when the design of the web-based learning resource started, was the team members’ knowledge and practical experience, draft version of the standardized work descriptions and some existing explanations of how to operate the technology. One of the nurses had developed a draft manuscript with concrete suggestions, and this served as a starting point for the group negotiations in the start of the project period.

In their first design meeting they exchange ideas about purpose and content in the learning resource. The stated purpose is to explain how scop-watch should *act*, including technical equipment, filling in forms correctly etc., explicate *responsibilities* as a scop-watch, and *communication* with other professionals. Their discussion leads to four modules “introduction; role and responsibilities”, “10-channel”, “telemetry” and “pre-hospital ECG”. The modules address how they plan to promote new practice and target problem in traditional introduction to “scop-watch”.

When the members meet the second time, they start to explicate the content in one of the modules; “10-channel”. The excerpt below illustrates how the group explore and interact in the content design of the learning environment. The discussion evolves around what the heading of one of the modules should be:

- 1 **Eline:** ... and then you have to think about .. is “10 channel” an OK heading here ..
- 2 **Gro:** JA, I think so, ABSOLUTELY
- 3 **Eline:** Ja ...
- 4 **Gro:** ja, it says just what this is, WHAT we are talking about, WHAT .. there is no doubt what we are to be talking about Or ?
- 5 **Ellen:** .. is it [no doubt] ...
- 6 **Gro:** .. are you in doubt ?
- 7 **Ellen:** ja I am not sure
- 8 **Gro:** .. laugh .. OK, oh well, why ?
- 9 **Ruth:** .. it depend what kind of explanations we include as introduction, I think
- 10 **Ellen:** .. because what is said in the procedures – “10 channel” .. It is nothing about ischemia monitoring or? .. I am just thinking out loud
- 11 **Gro:** ja, ja, I am also thinking out loud ... but maybe it is just in my head.. when I think “10-channel”, then I think ischemia monitoring
- 12 **Ruth:** .. but if it is explained
- 13 **Ellen:** .. but isn’t it .. because “10-channel” is only the cable, but ischemia monitoring is what the cable should be used for
- 17 **Ellen:** .. because we only talk about the cable when we say “10-channel”, but ischemia monitoring is both what is at the scop [central unit] and at the patient’s room [bed side monitor]
- 18 **Gro:** .. but can’t we settle for it ... then we say ischemia monitoring
- 19 **Eline:** .. you have to think about, consider carefully because this is ..

- 20 **Gro:** I understand that
 21 **Ellen:** so you like to use “10 channel” [directed to Gro]
 22 **Gro:** no, no – to me this is not a big deal, it is just that in my head - “10-channel” is ischemia monitoring, when I think “10-channel”, I think ischemia monitoring .. and that is .. what we want
 23 **Ellen:** I think that the focus is very much to that it is just a cable – but we want to shift the focus over to ischemia monitoring

This interaction expresses two perspectives about this aspect of scop-watch work, and what is important as valid knowledge for training nurses for this function. The different perspectives are visualized through two different positioning in regard to precision of language the learning environment should reflect regarding subject matter. The perspective leans either towards the instrument – “10 channel” as a cable – or the activity where the cable is one component in “ischemia monitoring”. When Gro uses “10 channel” she position herself as a practitioner and member of the local setting. By using the everyday language from the work setting, she emphasizes the expressions adapted during socialization into this practice. She explains that to her, talk about the instrument embeds practical knowledge and several assumptions of what this is about (passage 4, 11 and 22). Ellen challenges this when she raises uncertainty around the heading (passage 5 and 7). She points to what she sees as a lack of clarity in their procedures (passage 10), and suggests including what the cable is used for (in passage 13). Her suggestion expands their focus to activities at the bedside monitor and in the central unit (Passage 17). Gro points out similarity in purpose, just different expressions (passage 22). The conclusion by Ellen in passage 23 “.. we want to shift the focus over to ischemia monitoring” expands focus and directs development of the learning resource. This exchange is an example of tensions between different positions, staying close to current, local practice or externalizing practical knowledge and explicating embedded assumptions about practice.

As they continue to develop the content they rename the module “ischemia monitoring” following the conclusion above. This expands emphasis and content of this module. They collectively create a manuscript explaining what needs to be included in the learning resource to explain best practice for “ischemia monitoring”. Focus is on desirable actions for this activity, suggesting routines for information overview about the monitored patients. Also, they identify problem areas where the monitoring technology is not used to its full potential, including calibration of monitors, alarm settings, and retrieval of information stored in the monitoring technology. Hence, in the manuscript “ischemia monitoring” explicate the responsibility as

“.. observe, register and document the heart rhythm, frequency [pulse] every shift, record full patient name, room-number and rhythm, and select appropriate monitoring scheme; ischemia monitoring, 10-channel, 6-channel, telemetry” (Ruth explaining content of the manuscript, passage 29, 33, 35, transcript of 3rd meeting)⁵.

To target the problem areas, they suggest interactive sequences in the web-based learning resource to simulate how to use the monitoring technology for “review and adjust alarm limit at the bedside monitor” and “print 24 hour ECG - trends”. Such planning efforts illustrate knowledge produced in the interactions, and how articulating specific aspects of practice becomes represented in the web-based learning resource.

The chosen LMS and template-based authoring tool are examples of two standard solutions learning tool developed for local use in any work life setting. The tools carry with them the theoretical, practical and technological appraisals of the developers in their design, and these properties of the tool is of course likely to influence the local adaptation process. The LMS (SmartLearn LMS) provides tools for implementation and administration of the courses. Mohive Publishing system, is integrated with the LMS. This is an authoring tool for content

⁵ This is summarized from their discussion about content of the manuscript to design the learning environment to emphasis “ischemia monitoring”, (source: AhusKardio291007T2).

construction process, and provides the interface to the course content, and media repository for storing, grouping, searching, and manipulating content. The authoring tool does not require in-depth technical skills and the users have access to a set of templates for creating content in the form of exercises including multiple choice, drag and drop, video, explore and many others. The available templates allow combining text, pictures, and asking the user to complete statements or tasks. There is limited number of characters for explanations, requiring clear-cut sentences.

In our observations we see how creation of the manuscript for the content and foreseen use and adaptation of the templates inform each other as they model interactive sequences. In the web-based environment – the artifact – there is extensive use of pictures from the unit and of the equipment. They used these pictures in interactive explanations and assignments modelling future practice. For ischemia monitoring they created sequences focusing on correct placement of the ECG electrodes, and calibration of equipment and “adjusting alarms” at the bedside monitors. The resource explained and illustrated recommended practice to keep the overview, and activity at the hub, and a sequence to complete “print ECG trend” for introduction and rehearsal. Hence, “simulating” functionalities from the technology rich environments as interactive sequences in the web-based learning environment would explain operations and expand the repertoire of actions and explicate responsibilities.

We interviewed several pilot users to get information about the web-based learning environment as a resource for introduction to the work as scop-watch. These informants had some practical experience as scop-watch. Our findings show that the interactive environment communicating best practice as scop-watch was useful as introduction. The informants pointed out use value like

.. for newcomers this must be extremely useful, because it is so visual. You recognize when you are in the situation [everyday practice] ..it's very basic (#1).

.. I like to do things as perfect as possible, what is right, so I would change how I perform [the procedure] .. [when] everyone receive the same instruction, everyone will do exactly the same. .. individual instruction can leave out this and that, or run out of time.. here, one is a hundred percent certain.. person has received the information about how things are done, this is correct. It's a security. Quality assurance.. (#3).

.. it is very good. The technology and the HUB “Skopet” is the big .. uæææ .. [this] reduce anxiety [being scop-watch]. Maybe you can access [learning resource] the day before if you know you shall do that [scop-watch] the next day. I hope they continue to develop (#2)

.. [module] of bedside monitors, connecting the patient and calibrating the equipment and setting alarms is part of the introduction, .. to explain how to use the monitoring technology. Smarter to introduce them to this [web-based learning resource] early .. communicate routines and best practice. (follow-up, #6)

The extract from the first informant point to the value of the course for newcomers, since the use of pictures visualized everyday practice, but not as suitable for more experienced nurses since the course is basic level. The next extract illustrates a particular view on knowledge, suggesting one right way to do a particular procedure. The third and forth passage points to the web course as scaffold or tool for preparing for this work.

Modelling expected performance and interactively explain how to use more of the functionalities in available tools is an opportunity to streamline work processes and migrate to best practice. One of the users commented on the simulated sequences of calibrating the bedside monitors and “adjusting alarms”. She offered a practical example for inclusion of more content

.. we often have patients that, when they come to us in the beginning, we put them on 10-channel, and then some days later the patient get better and we put him on rhythm monitoring .. as you transfer the patient from one scheme to another, then you also transfer the ST-alarms [settings] that is saved for the patient, and then with noise and other things ST-alarms on the telemetry often goes off (#5).

The interviewed nurse points to a practice related problem, and suggests adding content in the resource. That is externalization of more aspects of the work. Other interviewee reflected on the interactive sequence “print ECG trend”, like

.. it was another thing also, it is supposed to be a routine every morning, but I do not think it is well incorporated .. To print trends .. it was also in the program, and it involves a few tricks (dikkedarierer), so that was good, as a reminder (#4)

This excerpt point to a possible problem in current practice since the information was not necessary used in the care and treatment

.. but I know that some are a bit ingrown, and would think it is not necessary. A good example is that one is supposed to print trends every day. Ischemia monitoring and trend for the past 24 hours, how it has developed, but when it's not used by the physicians, when they don't use them and don't look at them, .. the nurses just print and print, day after day. Many [scop-watch] don't print them, but it's one of the tasks, it says so here [points to the learning site]. It's bad for the patient .. developing an infarct that could be stopped at an earlier stage if someone had paid attention to the trends.. (#3)

Their discussion exemplifies talk about focus of the activities in the web-based learning resource. Interactive assignments and explanations was a strategy to introduce and rehearse actions and responsibilities for the scop-watch.

Transformation and contribution to new practice over time

This example illustrates how collaboration in processes to construct a web-based, interactive learning environment can play out. We elicited pilot experiences with web-based learning environment “*skopvaktfunskjonen*” [scop watch] from 5 pilot users. They were interviewed, and we reviewed the web-based tool as an artefact (Gauperaa, 2008). The experiences focused towards

- expressions about the *design* of the web-based tool?
- expressions about the tool's *usefulness* for knowledge creation and dissemination in the practice community?
- expressions about the tool's *status* for knowledge dissemination and creation in the practice community?

We focused towards further understand the tool's capability to contribute as information and knowledge resource in the practice community, and how the community view it. In the artefact review the focus is towards the strategies implemented to customize/design the tool. This focus on how the design /customization relates to goals and purpose set out for the tool, and complement the informants' perspectives.

The review of the artefact contributes information that complement pilot experiences and how the design/customization contributes to goals and purpose set out for the tool. The web-based learning resource specifically focuses on equipment, procedures and routines for monitoring emphasizing variations and deviations, early interventions, alarms and communication. Interactivity and multimodality led to a learning environment where the users could practice sequences of authentic tasks in a virtual or simulation environment. Simulations like this can provide safe places to practice, and allow for perfection of skills, and reflect on performance (Einarson, Moen, Kolberg, Flingtorp, & Linnerud, 2009). Overall, simulating and modelling authentic tasks in a web-based learning environment and allowing practitioners to practice them, plays a major role in development towards a more skilled practitioner. Emphasizing routines and skills is important from an institutional perspective, and adds to the overall professional development for the individual (Gauperaa, 2008).

Analysis of the semi-structured interviews shed light to the first user-experiences and how this approach to competency development is received. Several informants emphasize mastery of new concrete skills to perform aspects of the activity “scop-watch”, and work according to same principles and work descriptions (Gauperaa, 2008). This is captured in quotes like:

It was a collection .. intense, compact part of practice at the scop [central unit] what you are supposed to do of the administrative function .. sort of. It was OK to understand, what you are about to go through (#5),

.. Everyone receives the same instruction so everyone will do exactly the same. With individual instruction can leave out this and that, or run out of time .. but here, one is a hundred percent certain .. the person receive the information about how things are done, this is correct. It's a security. Quality assurance .. (#3).

When the informants were asked about the level they found the content to have, they provided feedback like:

.. For newcomers, this must be extremely useful because it is so visual. You recognize when you are in the situation [everyday practice] ..It's very basic (#1).

.. Some was rehearsal, but learned something new .. for example if we receive an ECG from the ambulance we can forward it to Riksen [national hospital]. That is new. It is very well possible that I have heard it before, but I have forgotten (#4).

.. Should include more and maybe a higher level .. more about heart rhythms, recall of rhythms that is the most important aspect of our work.. Maybe something like "if you do not recognize this rhythm, go to his page (#2).

Their perception of the web-based learning environment is as an information- and knowledge resource. They either emphasize everyday practice and experience as the most important or emphasize directions by work descriptions found in PPS and/or EQS. We also challenged informants to identify areas for further development and if there were suggestions to complementing content in the learning resource:

I thought a little .. we often have patients that, when they come to us in the beginning, we put them on 10-channel, and then some days later the patient get better and we put him on rhythm monitoring, with telemetry and they are walking around .. then we use a transfer procedure [on the scop].. that could have been included.. as you transfer the patient from one screen to another, you transfer the ST-alarms [settings], and with noise ST-alarms on the telemetry often goes off.. what we usually do is to turn that [ST-alarm] off .. the ST-alarms is not necessary with telemetry, because that is only rhythm monitoring (#5).

Lastly, we asked them what they thought about the simulation sequences and the possible impact for their practice as "scop-watch" and, ultimately, patient safety. One of them said:

Some are a bit in grown. A good example is that we are supposed to print ischemia monitoring and trend for the past 24 hours, how it has developed, but when it's not used by the physicians, ..they don't look at them, .. then nurses just print and print, day after day. Many [nurses] don't print them, but it's one of the tasks, it says so here [points to the learning site]. It's bad for the patient .. developing an infarct that could be stopped at an earlier stage if someone had paid attention to the trends.. (#3).

The findings show that informants are overall quite satisfied with the web-based learning environment, especially the strategies to establish familiarity by pictures from the unit related to the tasks and by interactivity in the different tasks. They also expressed satisfaction with several sequences, especially those that attained authenticity by pictures from the unit related to the tasks (Moen, Nygård, & Gauperaa, 2009). The informants' suggested that with the current content and level of difficulty, the learning environment would be most useful and appropriate as introduction to the work "skopvaktfunksjonen", and not for certification/re-certification.

Explicating knowledge and experience that accumulates and model activities in a new tool like this web-based learning environment present knowledge and experiences to different groups in different places and at different times. As a tool to support transformation of practice, in the follow-up interview the interviewee pointed out

.. people are more attentive to ischemia, and the part with ischemia monitoring, they are more dutiful .. make sure you have connected the patient properly [refer to placing ECG electrodes & calibrating the monitor], .. before .. were not so considerate about that. .. I find this a very important tool.. (follow-up,#6)

The informant relates an observed change in attention and practice to use of this web-based learning resource. This point to changes and transformation linked to how knowledge and

practical experiences are explicated and built into the different activities in the new web-based learning environment (artifacts).

Outcomes and open questions

From this longitudinal study into evolving transformation of practice we have illustrated two examples of how practitioners approach processes of consolidating work descriptions as part of a comprehensive knowledge management infrastructure. In an everyday practice that may seem increasingly fragmented and at the same time growing in sophistication and complexity, a repository of work descriptions may be a tool and resource providing easy access to updated knowledge, accumulated experiences, expertise and routines across time and space to ensure health care quality and patient safety. In this process, their traditional conceptions of practice emphasizing the habitual and rule-governed features of practice should be challenged. The exchanges and resources they mobilize illustrate shifts between the performance of 'packaged' routine procedures and differentiated practice, common to notions of knowledge work as solving ill-define problems, engaging in constructing knowledge and appreciating routines. The consolidated repository of standardized work descriptions is also a learning infrastructure, subject to change and transformation on several dimensions, e.g., in terms of implementation and negotiation of knowledge, experiences, standards, technologies and procedures when they engage in object oriented activities.

As an initiative to improve the introduction programs to specialty practice, we have followed how practitioners articulate aspects of their practice, and design an interactive learning environment where the learners – nurses that will work as scop-watch – are provided an environment that “simulate” how to carry out aspects of the work. This web-based learning tool represents historically new dimensions to introduction to specialty work, as the practical doing and representation of knowledge for this is tightly integrated. They can learn to practice as they work through assignments practicing important aspects of the work. Pilot experiences indicate that the tool is seen as most useful and helpful for rehearsal and repetition of procedures and illustrate how to practice in the unit. So far they especially pointed out the tool's role as reminder to utilize and keep up important routines for early detection, diagnosis and treatment. As such, they are exposed to the technology rich environment they will work in before they practice in the real life situation, and they can develop proficiency, knowledge and skills to carry out the work at the bedside or at the “hub”.

With regard to the evolving knowledge management infrastructure's status as a information and knowledge resource, we find an interesting interplay of two different perspectives; everyday practice and experience as the most important guidance, or emphasising formalized descriptions, for example found in PPS or in the web-based learning environment, as recommendations. When asked, all of the informants suggest consulting with a colleague rather than look up in the digital knowledge resource to get answers to questions at hand. An open issue for further investigation is how to maintain an evolving pool or repository of work descriptions that is found as current and valid knowledge, and provide timely access. It is also an open issue warranting further observation how the use of the work descriptions are used, to give direction for practical doing and as part of the process to represent professional judgment. Hence, challenges and tensions needs to be further investigated and elaborated in intersections of work descriptions that aim to regulate activities in the hospital, and current operating rules, traditional division of labor, and multiple views about the tool among different stakeholders.

Exploring ease-of-use and access to the knowledge management infrastructure, processes to keep up with content evolution, accumulating experiences and knowledge creation are important for tool-mediated production processes. We will follow up how this plays out and influence on-going transformations. The insights from this case study provide insight to the

use of the available resources and the role of tools in an on-going practice transformation. For KP-Lab this also allows for systematic future comparison of different examples of scaffolds for transformation of practice. In the ongoing iteration of fieldwork we investigate how the knowledge management infrastructure, including standardized work descriptions and an interactive web-based learning, are used as resources for development of new practice in health care work

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3.4 Interdisciplinary Knowledge Practices in Nanotechnology

“Old” Technology in New Hands: Tools and transformation of practice

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In this case we focused on the role of tools and instruments in knowledge production, and explored how instrumentation can play out in everyday practice in a leading edge domain. We studied nanotechnology, a leading edge knowledge practice, and the interdisciplinary work of chemists, biologist and physicist to produce nanoreactors. Nanoreactors is an environment for experiments that can make it possible to carry out high-speed controlled experiments on the molecular and sub-molecular scale in a cost-efficient way, and this is envisioned used for pharmaceuticals and energy development. To gain insight into the everyday practices of tool-mediated experimentation data was collected from interviews and observations in a laboratory, supplemented by review of their lab-books, reports and articles.

Introduction

The laboratory constructed what they call a “digital microfluidics station”. This can be described as a hybrid tool, or a combination of tools and instruments used to carry out experiments by a multidisciplinary group of scientists. It seems that they continually create gaps between their expectations and practical use of the tool as they are modifying existing knowledge or creating new knowledge as they advance microfluidics technology. In closing these gaps the scientists adapt the tools and create new knowledge to advance their practice. Analysis of everyday practice in the lab shows that the scientists appropriate microfluidics technology and use it for biological experiments. However they are regularly experiencing situations where problems occur and the technology needs to be modified, i.e., tuned, in order to carry out and complete their experiments. By solving these problems and making necessary changes they are developing a more robust technology, which can be used for a wider range of potential experiments. They are modifying existing knowledge or creating new knowledge and in so doing are advancing microfluidics technology. One of their approaches is by incorporating their new knowledge into the tools where it is accumulated for themselves and others to use in the future. Some of this new knowledge will also be presented in their scientific publications, particularly where they explain about the method used. However, much of this new knowledge may remain unarticulated as part of routines and habits in the lab and perhaps not very well understood.

The theoretical perspectives on knowledge encapsulated in tools (Baird, 2004) give some insight into how some of the expertise developed in the U.S. was shared with scientists in Europe and how technology developed by physicists could be used by biologists without all the users needing a full or comprehensive understanding of how or why the tools work the way they do. The theoretical perspectives suggesting more dynamic rather than static tools (Knorr-Cetina, 1999; Pickering, 1995), which are simultaneously used and changed gives some insight into the continuous tinkering observed in the case study. By linking together these different theoretical perspectives in a common conceptualisation of tools, the contribution of both previous and present use of tools in production processes and knowledge creation becomes more evident.

Major findings – tools in knowledge construction

The empirical data showed that the practice in this laboratory evolves following how users are using the tools differently or ‘wrongly’ compared to original purpose, adapting or re-building the tools. By conceptualising tools as the bearers of encapsulated knowledge and as being in a state where they can both be used and developed at the same time, it becomes possible for us to understand the role which tools may play in the development of knowledge. By examining the everyday practices, or the tools “in use”, it is possible to gain a better understanding of

how tools mediate process of knowledge creation. This highlight processes of instrumentation in collective knowledge creation when

- scientists bring a new tool into their laboratory, they also bring the opportunity to learn from others who have used the tool before them, however this is also opportunities to use the tool wrongly or differently and in doing so, to potentially generate new knowledge.
- a heterogeneous group of scientists uses a tool, it seems that they are continually creating gaps between their expectations and the practical use of the tool. In closing these gaps the scientists adapt the tools and create new knowledge.

An example of *using tools differently or ‘wrongly’* in this laboratory took place when a biochemist was trying a new combination of fluid, device and enzymes in the droplets. The combination did not work as expected. Interpreting this from the biologist perspective, the combination of fluid, device and enzyme did not lead to advancement, but the physicist recognized a similar phenomenon, and being able to recognize and reproduce led to better understanding of how to re-create situations in the microfluidics technology. Another example from our data illustrating *adapting the tools* was when they expanded functionality of an optical filter to make the laser beam shine in a line across the droplet, thereby making it impossible to miss any fluorescence in the droplet. Such expanded functionality was subject to critical testing by the biologists and represented a new method for detecting fluorescence in smaller samples. An example of *re-building the tools* followed one of the biologists who decided to build his own microfluidics station, suggesting improvements, opening up the black-box and exploring some of the knowledge accumulated in the microfluidics station. The knowledge of how to construct a microfluidics station was no longer the exclusive domain of the physicists, and although the biologist did not understand all components in the theory encapsulated in the technology the new tool worked to his satisfaction. Such findings illustrate how tools can contribute to transformation of practice from new opportunities when the scientists experiment with, appropriate and interact with the tool in different ways. This highlights processes of instrumentation in knowledge construction and transformation of practice because when scientists bring a new tool into their laboratory, they also bring opportunities to learn from others who have used the tool before them. We have illustrated these different, dynamic ways as using tools “differently or wrongly”, “adapting the tools” or “rebuilding the tools”.

Tool-mediated Knowledge Creation

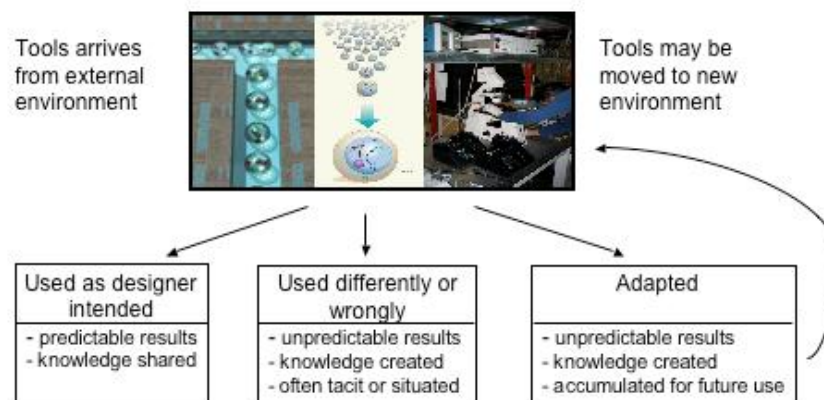


Figure 1 Tool-Mediated Knowledge Creation

The tool arrives from an external environment and the ways in which it is used can be grouped into three types:

1. Using the tool as the designer intended and producing the expected results. In this case knowledge would be shared between groups of scientists.
2. Using the tool differently or wrongly, either deliberately or accidentally, can produce new knowledge, which may become embedded in local practice.
3. Adapting or rebuilding the tool. New knowledge is created and made available to local users and accumulated in the tool for potential future users.

By using the concept of tool-mediated activity, we understand knowledge creation as happening when actors interact with tools. We need not confine ourselves to interactions occurring when the technology is used in the way it was meant to be used, we can also include the wrong use of technology or when the technology is being changed. These are all interactions with technology. The framework identifying different instances of tool-mediation in figure 1 shows the different ways in which tools contribute to knowledge sharing and knowledge creation. We might expect that with repeated practice some of the knowledge would become embedded in their routines (Nelson & Winter, 1982). In this case the biologists are still in the process of mastering the technology and for them “routinization” of knowledge has not occurred. The scientists all talk of “optimising” the technology as if one day it will be perfect and there will be no need to make new adjustments. This day has certainly not arrived, nor indeed has the technology become an invisible or transparent support to their work. The scientists regularly puzzle over which parameters, such as temperature or fluid concentrations, they might change in order to make their experiments work.

This analysis shows us that tinkering (Knorr-Cetina, 1999) or tuning (Pickering, 1995) happens daily in this environment. By extending the analysis backwards in time we see that this is not just something occurring in the current lab, but has probably been going on all the time. The knowledge creation and production processes during this type of activity have been very different. One example is a path-breaking change leading the emergence of this branch of microfluidics from using microchips “wrongly” by putting fluids through them. The example of addition of motor and extending the range of enzymes that can be experimented on may not have radical effects, but illustrate incremental changes that expand the range of experiments that can be carried out using this technology. The exploration to make synchronisation of droplets easier, and a new nano particle was discovered, exemplifies the relationship between unplanned tuning and transformation (Pickering, 1995). Without paying attention to everyday tuning the relationship between this activity and some of the more important “transformations” might not be so evident.

Many studies of technological development analyse the outcomes of the knowledge creation process for example in the form of publications or patents. Such studies are likely to miss the dynamics of the on-going practice and not be able to assess the role played by the technology in this process or to see how the scientists chose from available options when confronted with a problem. In this study of on-going practice and the historical development of this technology revealed the path the development of the particular microfluidics station and the microfluidics more broadly. We started with some of the ideas of Derek de Solla Price (1984) and others on the importance of instrumentalities in the development of scientific knowledge. This case supports the suggestions that tools and instruments draw scientists together and they build their communities around them. Through the history and the development of this branch of microfluidics technology the ever-changing technology used in the experiments has played a role in the composition of the team of scientists involved in experiments, developing their knowledge by using it and making the technology work. This exemplifies instrumentation where use of, experimentation with and creative modifications of tools accumulate

knowledge, and play out in the “problem space” of conventions within collaborating disciplines, stabilized routines and multiple voices of what counts as knowledge. Therefore, the findings from the case demonstrate several ways in which instrumentalities are contributing to knowledge creation by transformation and tuning (Pickering, 1995), and transform tools and practices to move a leading edge research field like microfluidics forward.

Implications for KP-Lab tools and infrastructures

This case study from a leading edge research field – bio-nano technology and microfluidics – gives several important insights for the KP-lab project. To start with, the case study demonstrates the trivial aspect that instruments and tools is an embedded part of the production of scientific results. What’s less trivial is their developments through iterations of experimentation and tuning the instruments in order to stabilize the scientific practice. Such finding breaks down the difference between routine work and innovation. One could argue that running the experiment is routine work, but as findings from this case points to, the process of stabilizing the instruments is part of the innovation and knowledge creation processes over a long period of time. We argue that this would be the case for the development of new tools and infrastructures in KP-lab as well. To intervene with and stabilize new tools takes a rather long period of time, but through longitudinally and iteratively designed in-depth studies we can explore potentials for innovation.

The second aspect is that the interdisciplinary nature of the nanoscience has strong resemblance to developing tools and environments for learning. In this case the everyday knowledge practice materializes in a hybrid shared space where knowledge and expertise of traditional disciplines are shared between participants and places. The object of improvement and innovation is shared by the participants. However, individually they have only partial understanding of why and how the tools and instruments in the digital microfluidics station works. Hence the meanings generated from the experimentations differ given the background and knowledge people have. The three groups of scientist involved from chemistry, biology, and physics, draws out different scientific results based on the preparation to, carrying out and/or interpreting the results of the experiments. These interdisciplinary aspects provides for analytic benchmarking of how KP-Lab’s tools contribute to knowledge creation and dialogical learning. This relates specifically to three intertwined aspects, the co-design processes of different tools, connections between the accumulating knowledge in the tools and the actual use in different contexts, and the generated meanings that the participants’ draw from experimentations and tool use.

The third aspects we will highlight relates to deliberations of what you want to automate and what you choose to represent as non-automated processes in support of knowledge creation. In this case study the development of the microfluidics technology is *internal* to the production of scientific results, in the sense that it leads to iterative changes and transformation to advance the knowledge practice. The tools are part of the ‘chain’ that creates knowledge, but the tools must be integrated with the human reasoning about the knowledge produced to contribute to innovation. The question then for KP-lab becomes how tools and instruments are part of human learning; and in particular knowledge creation or dialogical learning. We think it is necessary to conceptualize tools as *internal resources* for learning building on accumulation of available knowledge, and as *external resources* that can contribute to and enhance the learning processes indirectly. To boost learning of specific knowledge domains designers can easily build technologies that make invisible some categories or parts of the body of knowledge and emphasize or make visible the knowledge categories students or workers need to learn. Cognitive tutors in mathematics provide an excellent example of technology that is internal resources to the learning activities in the sense that the premise is that the students work with knowledge that is given. On the other hand, the KP-lab project

works under different assumptions and ideas since the creation of *new* knowledge for the participants is the key focus. If tools with built-in knowledge categories are external to the participants they are available, but can be ignored without a break down in the activities. If the resources are internal the participants must use them in order to perform the activities.

Therefore the relationship between tools as internal and external resources in production processes becomes critical, and how to design and provide the users the ‘best’ mix of resources that are internal and external is a key challenge for KP-Lab. In contrast to generic collaboration-oriented tools and instruments with the intention to structure social interaction, KP-lab’s tools aim to go beyond this to scaffold collaboration as productive, collective knowledge creation processes. This means that resources to scaffold collaboration do not intent to automate human action per se, but provide resources for more advanced reasoning based on the type of problems that must be solved. To nuance this argument we claim that the semantic layer in the KP-lab platform provides a level of intermediate abstractions towards a common platform for creation of tools that accumulate results of previous activities and structure for further collaboration. This may be valuable for collaborative knowledge creation processes and it combines features of internal and external resources in tools for human learning. How the distinction of internal and external resources can be productive and utilized when designing tools for knowledge creation processes in educational and/or workplace settings needs to be specified further and complemented by other case examples.

The fourth aspect we will point out is the horizontal development dynamics and expansive learning in activities of co-configurations of tools and working processes as demonstrated in this case study. In the everyday practice we studied, the scientist contributes their knowledge and expertise, but have only partial knowledge of all the production chain leading to full use of microfluidics and bio-nano. Their knowledge-creation expands beyond accumulating existing knowledge and experiences available in their network. The emerging knowledge and experience accumulates in the tools and instruments, enabling the scientists to create, share and disseminate knowledge to different groups in different places and at different times. Their expansion take the form of incremental development – tuning - or co-configuration of tool and social practice when refining or improving efficiency of existing techniques or transformation when the tool are used and developed at the same time. This exemplifies that when putting “old” technologies to new uses, the tools are playing important roles in creating and sustaining networks that links the object of activity, in processes beyond accumulating experiences and existing knowledge in a network to historically new forms of knowledge creation.

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3.5 Development of Activity System Design System

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The ASDT study includes two main lines of analysis and data gathering, namely, 1) the design process of the ASDT of KP-Lab and 2) the piloting of the ASDT in the networks of work life development. The piloting has thus far concerned limited experimentations at Pöyry Forest Industry, the KP-Lab partner in charge of the main ASDT design work. The first line of research is reported here, after which it will be closed, while the second line, the piloting, will continue to be in the focus. In the time of this report, pilots are about to start in the dissemination network outside the KP-Lab partner organizations.

Introduction

The design process of ASDT/KP-Lab has been documented from the beginning of the project. The aim of this line of research is methodological and partly evaluative. Methodologically we are searching for ways to analyze the multi-level, multi-perspective and multi-voiced design of learning tools, which would pave way to the dialogic approach and related methods. Evaluation part is directed at the collaborative design practices in the frame of the KP-Lab: what can we learn about the design process evaluated from the point of view of the dialogic principles and practices? This report is based on the analysis carried out and reported for the edited book of the KP-Lab (Toiviainen, Toikka, & Lallimo, submitted).

Design work for ASDT application started in spring 2006 when the design teams of KP-Lab organized. Two main components of the design task were figured out, the digital tool for the basic setting of the Change Laboratory® method and the video annotation application for editing visual mirror material. Since starting, the design has gone through several phases when specifying the design task and adapting to evolving project organizational changes. The phases are partly overlapping, not linearly proceeding, and named according to the main design object in respective phases.

Scenario phase was an initial step of the KP-Lab design to communicate across the project partners, how the pedagogical settings utilizing KP-Lab tools would look like in the future. A pedagogical scenario on “Virtual Change Laboratory Tools” described how the organization and implementation of Change Laboratory® would be supported and transformed by using ASDT.

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 kind of existing tools and technologies there are to be potentially utilized (Engeström & Toiviainen, in press).

Mock-up phase produced representations of the basic layout of the Change Laboratory setting (Figure 1), during which it became clear that building on existing tools is not enough but a specific application is needed.

Specifications phase started in 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 KP-Lab Shared Space application became more and more essential requiring growing design efforts, whereas in the Matrix phase and the Mock-up phase internal requirements based on the Change Laboratory method dominated. For this analysis, we chose an intensive series of design events from the Specifications phase in May 2007.

Major findings

As major findings we summarize the methodological elaboration for the triologic approach. This is done under sub-titles Knowledge creation setting, Activity theoretical approach, and Steps of analysis.

Knowledge creation setting.

In accordance with the KP-Lab assignment, the collaborative creation of tools follows the principle of co-design between the pedagogical and technological partners, and the prospective end users. This kind of approach is at the core of the concept of triologic learning that in our understanding is a multi-perspective and multi-voiced process laden with contradictions. When properly grasped and analyzed, these characteristics may be turned into social innovations. To achieve this, the research setting was designed to embrace the fabrication of the object of activity, the artifacts to be designed, and the participants with various interests and insights, as well as the activities in which these are embedded.

This study continued a previous analysis of the same ASDT design process, in which the construction of the object was seen as a learning process of a multi-disciplinary design team (Engeström & Toiviainen, in press). It was argued that learning takes place through constant questioning, reopening and redefining of the object split by contradictions. Now we extended the analysis to look at the object construction at several levels of activity and to focus on *the variety of object construction and knowledge discontinuities across the levels* (Research setting, figure X.1).

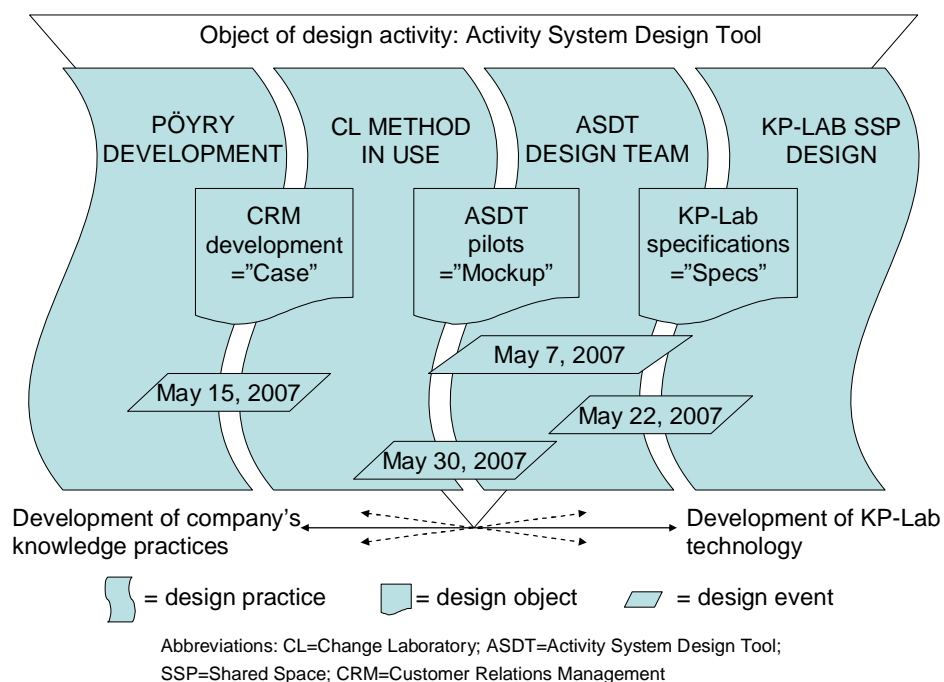


Figure 1. Research setting

Activity theoretical approach.

To grasp the practical and theoretical challenges of the object construction, we borrowed the concept of *co-configuration* used recently in activity theoretical studies (Engeström, 2004; Toiviainen, et al., submitted; Virkkunen, 2006). The historical phases of the production have evolved through the craft work to mass production, process enhancement, mass customization, and finally towards the present-day co-configuration type of production

characterized by the dialogic knowledge in a complex interaction between the producers, users, and the products to be designed and used.

On the other hand, the activity theoretical studies of developmental interventions have shown that the communities' efforts for change are fragile and contradictory often leading to breaks and discontinuities instead of innovative boundary-crossings and the expansive transitions of the object of activity. To grasp this, the concept of "rupture" was implemented in the analysis. The analysis of ruptures enabled 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.

The concepts 'co-configuration' and 'rupture' with a manifest object-orientation and an emphasis on the knowledge-creation aspect addressed the phenomena closely related to the concept of trialogic knowledge building. These and other activity-theoretically informed concepts are depicted in the analytical framework (Figure X.2).

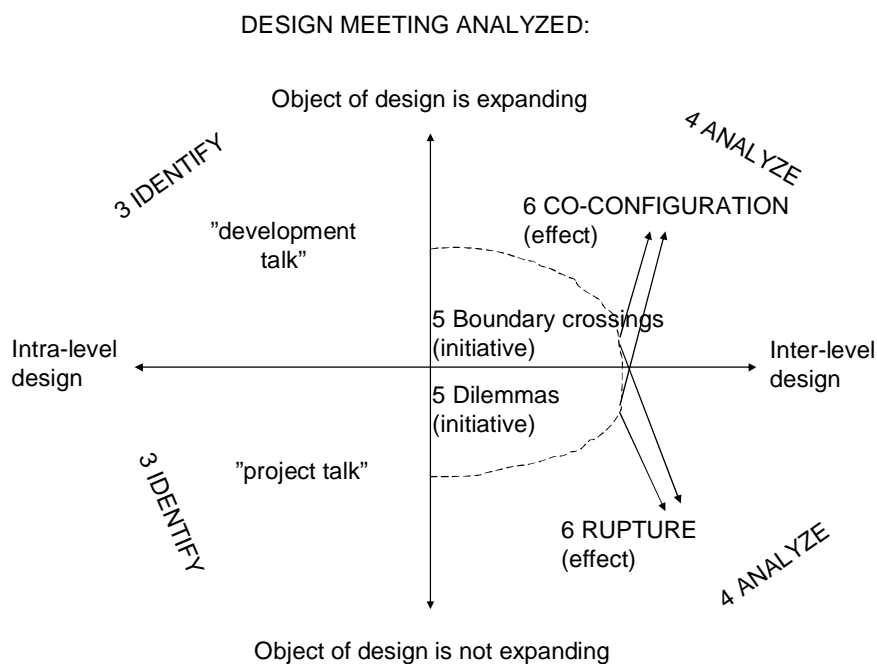


Figure 2. Analytical framework

Steps of analysis

With the help of the analytical framework the steps of analysis were outlined (points 3-6 in Figure 2):

1. Identify the design meeting on the trajectory of design, its aim and goals, the participants, and typical features of the discourse.
2. Analyze the design object presented and discussed.
3. Analyze and separate out the discursive episodes expressing intra-level development and project talk.
4. Analyze the discursive episodes expressing inter-level design efforts.
5. Identify and interpret discursive boundary crossings and dilemmas embedded in the episodes expressing inter-level design initiatives.
6. Analyze and interpret the effects of the boundary crossings and dilemmas observable in the design discourse: Will these initiatives lead to effects indicating co-

configuration (the object of design expands) or end up in rupture (the object of design is not expanding), which might be interpreted as enabling or blocking the dialogic knowledge creation, respectively?

7. Summarize and juxtapose the findings (co-configuration and ruptures) by relating them across the levels of design.

Discussion and some conclusions

This study aimed at a methodological development for understanding the multi-layered and heterogeneous design process and its expansive learning potential, all of which was aimed at the elaboration of the dialogic approach. The main data was composed of the discursive episodes in four meetings of different design settings.

Various design contexts gave rise to different inner tensions of the design object to be solved by collaborative actions. What seemed to be common to all of them, was the task of intertwining the general or formal requirements and the context-specific, “grass-roots” features more directly associated to the use value of the object: the structure given by the project vs. specifics of the ASDT (Meeting 1); rapid outcomes needed for the formal ASDT specifications vs. longer perspective to the development of practices of the company (Meeting 2); abstractness of the ASDT specifications vs. concreteness of the user perspective (Meeting 3); ASDT (written) functionalities vs. (visual) user interface (Meeting 4). In sum, the specifications of ASDT as the topical design object during the series of design events in May 2007, was simultaneously a connecting and a tension-laden source of knowledge creation across the levels of design.

Related to the notions of the design object and its tensions, it may be pointed out that – according to the interpretations made in the analysis – each of the co-configurations produced in the design meetings expressed the context-specific and use-value oriented knowledge expanding the object of design beyond the definition of specifications. The ruptures, on the contrary, were regularly associated with, or even produced by, the formal and general requirements serving the topical “specs” deliverable of the project. This unifying notion across all design contexts is critical for understanding the dialogic knowledge creation. It shows that the interest of participating in the design, making boundary-crossing initiatives and contributing to the co-configuration of the learning tool was motivated by the use-values envisioned on various levels. Given the orientation, the specifications as a design object was productive to the degree it could bond other design objects, such as the CRM development by the company and the ASDT user interface by the Change Laboratory users. In the period analyzed this was not too obvious; the specifications remained abstract to most of the co-designers therefore not encouraging boundary crossing and the expansion of the object, the ASDT design, in the best possible way.

Outcomes

We see that the R&D activities of KP-Lab should continue the investigation and elaboration of the analytical concepts initiated in this study. This will be done in the ASDT pilot studies but may be extended to other design studies, as well. The main concepts for analyzing the multidisciplinary, multi-perspective tools design were: *levels of design activity, inner tensions of design objects, co-configuration, and rupture*. Co-configuration and ruptures of the knowledge creation were identified in the intersections of the levels of design and in the tensions incorporated in the representations of the design artifacts. The results suggest that the dialogic knowledge creation and learning across the levels of the design activities would inevitably or inherently take place in a dialectical process of building tensions in the knowledge artifacts while at the same time seeking solutions to them.

The development of the analytical tools and concepts for identifying the actions of expansive co-configuration on the one hand, and actions producing ruptures, on the other hand, may help creating the favorable conditions for trialogic learning across the knowledge practices of collaborative networks. These are the preconditions not only for research but also for the tools to be developed. In other words, to be trialogic of quality, the tools should make visible and manageable the levels of activity in question, inner tensions of the artifacts created, as well as co-configuration and ruptures involved in solving the tensions of knowledge creation. Our methodological exercise, in which we developed and experimented with some analytical conceptual tools to grasp the dynamics of the multi-level design, is only a start. We offer the findings to be further elaborated and critically debated whereby the methodology called “trialogic” may ensue.

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3.6 Globally distributed design work - Virtual Mill

Jiri Lallimo, Hanna Toiviainen, Seppo Toikka, UH

This case explores knowledge intensive practices that are longitudinal, developmental and process-based. It investigates the expansive object of collaboration and the challenges in a work context that is distributed globally and that is mediated by engineering design technology, i.e., by the 'Virtual Mill' environment. The study contributes insight to mechanisms for transformation of practice, and for KP-Lab to better understand the triological learning and to develop triological methodology. By now, the study of 'Virtual Mill' has focused to the design phase of a project. The construction phase will start mid 2009.

Introduction

Pöyry Plc Forest Industry business is a global market leader in project engineering and implementation services for the pulp and paper industry. The ongoing transition from a locally managed company to a globally distributed network is a major challenge. In the locally managed, traditional engineering work the people work at one office and the design work is carried out by data management tools running in the company intranet. The distributed work casts expectations also for the tools when managing the communication and data of the networked design engineering. The distributedness means that the design is done in several places and that the data is shared between several stakeholders, e.g., design disciplines and design companies, the customer, the machine suppliers, etc. 'Virtual Mill' supports these aims. It is created during the course of a detailed engineering project, and serves all phases of the project; design, engineering, construction, installation, start-up, operation and maintenance. Although the 'Virtual Mill' concept and technology is not the specific focus of the study, a description of the concept serves to clarify the frames of technology intensive and distributed work. The 'Virtual Mill' environment consists of a 3D model, several discipline specific design systems, a database and documents, which together define the real plant, and a web-based user interface for access to any information or document required. In addition of the tools, the concept of Virtual Mill covers the idea of the lifecycle management of the product and design knowledge. A critical element enabling the distribution of engineering expertise in Pöyry is the 'Virtual Mill's' solution for creating, storing, maintaining, searching and accessing technical information on large industrial scale.

The life-time management of the data produces savings and helps to manage the complicated system. However, the changes expose inadequacy in the existing organization of the work, when the design tools change, the flow of information takes new forms and the workers are expected to expand their expertise in new communication networks. The study focuses on how the technology enables distribution and construction of knowledge, but also how the use of such technology creates problems on the systemic level of activity. The use of new technology in a new setting opens for transformation of the existing work practices, but also, the technology may carry (hidden) elements that are not fit for the desirable use.

Findings – an example

The data collection started by capturing the negotiations with the company, and continued with the actual project. The data corpus contains material collected as group and individual interviews, participation in workshops and important project meetings, a 'development-diary' accessible for the workers in the company intranet, observation of collaborative work, and review of project documents. The activity system and identifiable elements was the unit of analysis. From the data the researchers identified problems in the work, and the utterances presenting such problems were grouped under leading themes about transformation in the

elements of design project work. The researcher-interventionists brought this to the project members to reflect on for their work.

In the first workshop between the researchers and participants, the first findings concerning the globally distributed design project were presented and discussed. The presentation followed the methodological approach, highlighting the systemic nature of activity and using the model of activity system to bring in the problems raised by the people who represented different perspectives to the project. Figure 2.1 presents the model of activity systems and its elements represented in the workshop, and constructed between the researcher- interventionist and the participant workers.

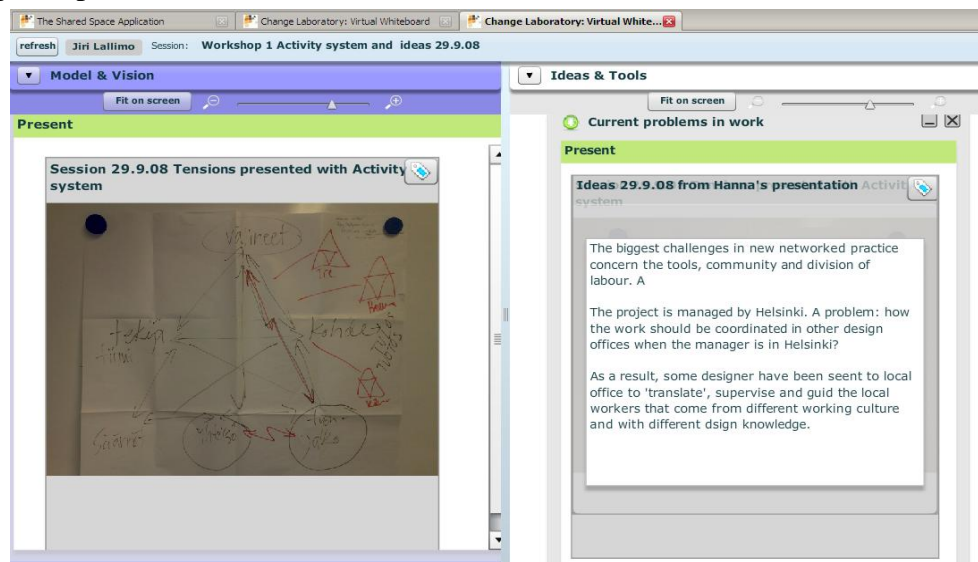


Figure 1: The Activity system⁶ and interpretations constructed to ASDT.

To start with, the researcher draws the model of the activity system and its elements, seen to the left in figure 1. Then focus of the session is described; to have a closer look to the emerging object of the whole project activity, the role and the nature of the tools, the new distributed community and the transforming division of labour. On the right side of figure 1., some of the identified tensions are recorded as they were constructed in the workshop. The model served as a shared reference, to briefly explain the systemic nature of the approach, and how several communities' activity systems can be approached at the same time. This required no previous theoretical understanding from participants.

The following excerpt of the workshop discussion shows how the participants raised different opinions about the changing elements in networked work.

Researcher/Interventionist: The reason I draw this kind of network here, is to see how much you as a centre of the project team have the coordination here or how much the new network partners bring in when you have to work as a network. These are based on our initial remarks on your project and now it would be interesting to hear your opinions about this kind of approach.

Project manager: At the moment the idea at the mastering of the project is here, otherwise this would not work. That figure that you draw, at first I thought what an earth are you trying to make, but I must say that you have a good point there. It's exactly the point what is changing here, that you modelled well. That 'downstairs' of the model [i.e. rules, community, division of labour], especially the division of labour and the community are changing.

Manager of the mechanical design discipline: Not only, ten years ago we did not have tools, and we could not have done this networked work.

⁶ In the first workshop the model was presented on white-board, and later transferred to ASDT for the purposes of KP-Lab reflection and development.

Project manager: Yes yes, but what I meant, was that especially concerning the networking is that those two parts are changing, and the tools are not changing because of the networking.

Manager of the mechanical design discipline: The tools give us a possibility to change.

Project manager: Unless there become other problems in the work.

Manager of the process engineering: Concerning the tools, we have started to make networked work models only three years ago, because we did not have the tools.

Other remarks were raised as a continuation to project manager's interpretation about what is changing in their networked projects.

1. *Designer of the automation design:* It has been a conception in the beginning that in the new foreign design office they do the mechanical design and we send the designer NN from Finland to guide that process. We did not think how the work is coordinated on the specific level. Now we have seen that there should be a coordinator and a head-level designer who can take in and transform the information from Finland head-offices to there.
2. *Manager of the mechanical design:* This only tells that again the tools and the internet connections are not working as fast and reliable as they should. The people in that office do not get the information they should. The data bits should travel in internet without any disturbance.
3. *Manager of the automation design:* The problems are caused because the coordination of the work is too much centralized in our main office. If we have the right people in that end to coordinate the work, we have no problems.

The underlined parts in the excerpt above point to dilemmas highlighted by the participants. The first speech acts bring up that in the information flow is problematic between two countries. The first and third act are linked to the new division of labour. The second speech act stresses that the problems are caused by the tool, the internet technology. They represent technology-oriented and project-coordination oriented views to the same problem.

When preparing the second intervention workshop, the researchers analyzed data carefully, specifically exploring episodes that represented problematic and tension-rich voices, as well as suggestions for solutions. They illustrate particular elements of the activity system, concerning the challenges of globally distributed design work. Using the model of activity system to frame the finding, the analysis revealed the following tensions;

ACTOR: the coordination team consisting of the discipline leaders and designer

The inner tension: A discipline designer vs. teacher of the other network.

The designers were used to take responsibility of their own design discipline. In the current networked project they are put into a position of teaching their expertise to the new distributed offices. This is difficult and they do not have the resources and the models to that.

OBJECT OF ACTIVITY: design project – OUTCOME: paper mill, design documents

The inner tension: - separated discipline objects vs. a common object of the network (shared), changing object.

The designers were used to see one part of the design project as their primary object of work. In the networked project they are required to have a more holistic view of the activities taking place in and between the distributed offices.

TOOLS: design, communication and coordination tools

The inner tension: design tools vs. tools for coordination and cross-communication.

The design tools have been used for design inside a discipline. Tensions arise when the tools also must mediate complicated questioning and commenting. The changing nature of distributed coordination has an impact to tools.

RULES

The inner tension: the existing rules vs. the emerging rules for networking.

The rules inside the company were formed during previous projects and were rather stable. In the current situation, there are several unexpected problems, which caused a need for change in the rules.

COMMUNITY: the coordination team and other design offices

The inner tension: - local team vs. distributed network.

The community expands from the local office where people know each other to networked setting where people do not know each other expertise.

DIVISION OF LABOUR

The inner tension: centralization and clearly defined vs. distributed and emerging.

The existing mode of working relied on local team and management. The clear division of labour between designers and disciplines is challenged when new design offices are included since they have their own practices, including assumptions of roles and distribution of work.

The analyzed data was organized for the second intervention workshop. The method of presenting and working on the material with workers followed the notion of dual stimulation (Vygotsky, 1978). The first stimulus was to show the workers concrete observational material of challenges of the work abstracted from the collected data, called “the mirror”. The second stimulus comes from theory-driven tools, e.g., models and theoretical concepts, and aims to start solving challenges seen in the mirror. The workers were invited to give their interpretation and ideas. Figure 2 below presents a view from Activity systems design tool (ASDT)⁷:

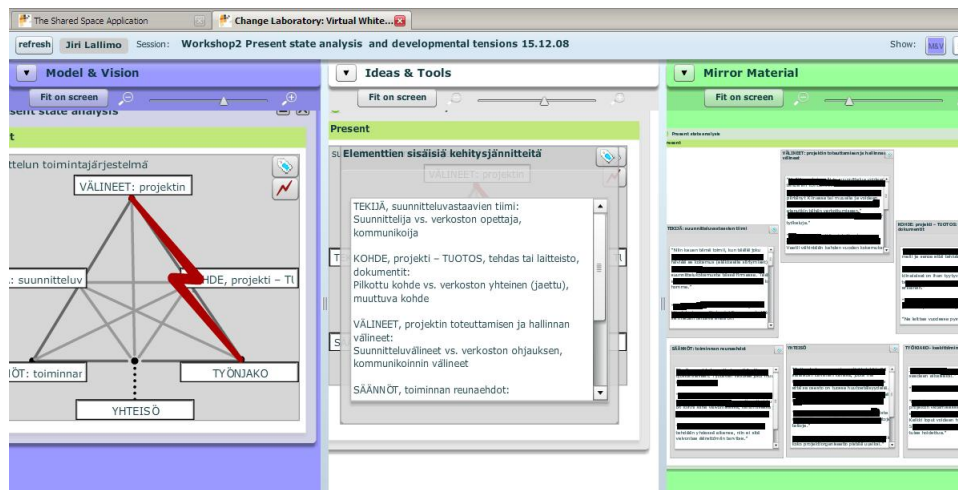


Figure 2: Presented in ASDT, the developmental tensions constructed in the session, the activity triangle(s) and the textual Mirror material⁸.

Textual mirror material is presented on the right side, organized according to the elements of activity system, the triangle of activity system in middle, and the suggestions of the tensions in the left side box. In this discussion the researcher-interventionists also presented hypotheses of the developmental tensions. The mirrors were a shared point of reference, supported by the analytical tools. Outcomes of their discussion brought up future actions for project development.

Major findings: Transformation and contribution to new practice

In this study the practice transformations were approached from several views. *Firstly*, transformations of practice materialized as an expansive object of work. In the traditional

⁷ In the beginning of the workshops, ASDT was introduced as a tool to organize and model the data. However, it was not used to represent the data during the workshop. Mirror material was presented with PowerPoint and the activity system model on whiteboard. The data is presented in ASDT for the purposes of KP-Lab reflection and development.

⁸ The mirror material blinded for this report

engineering project the primary object is designing the mill, and the concrete mill is the outcome. The practices are familiar to participants from previous projects and they do not require a major change. In the networked project several unexpected problems occurred. The extended new main objects of work had to be identified and resolved. This included new, distributed nature of the design tools, the new role of the actor (here, the design project group), and the new, networked community with new rules and division of labour.

Secondly, it is relevant to describe and understand the role of the artefacts that are constructed in the transformation process. In this study the artefacts included mirror material of the work, conceptual tools to model and describe the systemic nature of elements of work, and tools, such as ASDT, to represent the reflection and the construction of knowledge.

Thirdly, while the artefacts were seeds for the change and the tools were the interface mediating change, the transformation required an explicit pedagogy to support learning. In this study the pedagogical model, i.e. the plan and the arrangements to facilitate learning, followed the ideas of developmental work research and expansive learning. The idea was to bring the observations of challenges and redesign of the work closer to the daily practice while still keeping it analytical applying the systemic methodology. To achieve this, it is important to rise above the discussion and represent and preserve perspectives as material artefacts for later development iterations. In this case, the starting point for the company was felt shortcoming to manage the work in the networked, globalized environment. To start with, the presented problem was very general and rather unfocused: participants only felt that unexpected problems occurred during the project. Systemic understanding of the activity to reveal and explicate potential problems, and present them to workers as inner tensions of the elements of work is the strength of this approach. As the participants stated, this was helpful for getting focused on the problematic issues. In this sense, showing the mirror material and coming up with the tensions is an important mechanism preceding the solutions to the problems. This study showed that in order to transform the practices underlying elements have to be revealed, and provide the participants possibilities to rise above current practice and identify a lead to follow.

Fourthly, during transforming the practices of the network, the symmetric dimensions of the agency become important. In the context of multi-professional, knowledge – intense work, people carry high responsibilities in their work. Similarly, when transforming the work, several perspectives are invited to build a common frame for new practices. Typically it has been the project manager who oversees the project, suggest and implement the changes. This was clearly new to the domain experts. For the participants, this study represented a new way to see the work from a higher level and how inviting individual perspectives could contribute to overall view. Supporting the new agency is a prerequisite for the transformation process.

Implications to KP-Lab development

The study serves KP-Lab in the following perspectives. The results imply, firstly, to the understanding of the triological learning. The study explores longitudinal, developmental and process-based knowledge practices that are technology and knowledge intensive. It explored the expansive object of collaboration in a work context that provides unexpected challenges. The results are were summarized above, according to the analysis that was focusing to the situational and discursive episodes that were explored in the context of historical change of globalizing, and networking work.

Secondly, the case gives insights to the triological methodology. The reflection and development relies on activity theoretical learning concepts that are introduced by the interventionists and further used by the participants. This aims at dialectics between concrete data from the work and theoretical level that is supported by the conceptual tools, such as the

model of activity system, cycle of expansive learning and the dilemmatic elements of the work. The methodology involves that the collection and analysis of the data and the interventions arranged for the participants' reflection and construction serve for development and learning at work. The data – the mirror material collected from the work situations - can be reflected on and negotiated by each participant, and that this leads to suggestions how the work could be developed. The process and the outcomes are presented in the workshops and made understandable and meaningful in the work context by the use of models and other conceptualizations. The lesson from this study methodologically is that the dialogical methodology connects the elements of the design of the whole setting; on the high level, approaching the activity and the change in the context of historical continuum; work practices reveal their inner meanings when seen through their history; on the level of methods used for the data collection and analysis and; on the level of interventionist process of involving also the participants in analyzing and modelling their work. The work context, the learning environment, is not a separate entity that only the researchers and developer-interventionists can explore and manipulate, but a field of connecting research based tools and field-related knowledge of the work-practitioners.

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3.7 Adaptive Cognitive Systems

Jiri Lallimo, Sami Paavola, Seppo Toikka, Pasi Pohjola, Kai Hakkarainen (UH)

The "Adaptive Cognitive Systems" case is exploratory in nature. We have investigated a research group and their approach to automated learning algorithms and modelling methods for discovering and analyzing complex patterns from large amounts of data of linguistic and cognitive representations, and from social interactions between agents. We aim to give a particular view of ACS-group's conceptualization of the possibilities of automated data modeling methods. We illustrate ACS-group's knowledge practice when working collaboratively opened up by new data modelling technology. The aim of the study is to produce understanding for the triological theory and to the technology supporting practices.

Introduction

KP-Lab focuses on developing technologies for supporting innovative and collaborative practices of working with knowledge ("knowledge practices"). One aim of the project is that also the role of semantic technology should be utilized in the context of emerging social practices. The semantic elements are highly important in the light of arranging the data used or produced with new manners but also capable of bringing forward the hidden or emerging linkages and structures between the material produced. However important the semantics of the material is, KP-Lab is also concerned about the possibilities of understanding the role of practices with technology. In the background of the KP-Lab project is the "third" metaphor of learning (Paavola et al 2004; Hakkarainen et al 2004) as a "triological" approach. It examines learning as a process of creating, developing, and extending shared epistemic artifacts and transforming the knowledge practices accordingly. One challenge of the project is to develop ways of understanding the role of semantic technology in relation to the triological approach to learning. A central aspect is the relationship of semantic services to the practice perspective.

This brings the project close to emerging ideas of pragmatic web (Buckingham Shum, 2006, De Moor et al, 2002, Schoop et al, 2002) as means to make visible and support people in understanding and developing their practices with knowledge. With a short presentation to pragmatic web, we aim to gain understanding about the prevailing use and meaning of technology and the possible future orientations: a shift from artefact orientation in technology (describing the metadata and semantics of the artefacts) to combine semantics of the artefacts to the practices the artefacts are created and used in. By interlinking the emerging technical possibilities to support the knowledge intensive practices, the case "Adaptive Cognitive Systems" ACS brings forth the possibilities and the use of adaptive informatics by a high-quality research group. Their technological solutions and ways of understanding ontological modelling are different to the KP-lab project, and provide interesting reflection material for the project. It is important to note, the rationale of using the ideas and technology of ACS-group in the frame of KP-Lab is to cross-appropriate the ideas from different academic fields, and not to claim that ACS-specific technologies should be incorporated to KP-Lab as such.

Technology and practice turn

ICTs are profoundly changing the way people work collaborate, and communicate. Mastering advanced forms of learning and knowledge creation is a crucial challenge to societies aiming at sustainable innovation-driven development. Knowledge workers have to engage in systematic and deliberate efforts of knowledge creation throughout their professional career. Institutional boundaries are blurring and professionals work in rapidly transforming teams and

projects linking participants across organizations. Expert work is driven by open-ended and incomplete epistemic objects (Knorr-Cetina 2001).

Practices and pragmatist perspectives seem to provide a better way of transforming many methodological dichotomies still prevalent in learning sciences (between individualistic and social approaches, or between conceptual or situated approaches) (Johnson & Onwuegbuzie 2004). This growing interest to practices in many disciplines (in sociology, cultural theory, philosophy, science and technology studies) has even been named as “practice turn” in contemporary theory (see Schatzki 2001). The expansion of the conceptions of learning emerges also from the new information and communication technologies (ICTs). ICT provides novel way of re-tooling practices (Miettinen & Virkkunen 2005) but at the same time challenges our deep-seated conceptions of knowledge and meaning making.

From KP-Lab’s perspective of developing technology to support triological practices, the emerging ideas of semantic and pragmatic web are interesting. In order for the semantic web to be usable, the data should be represented according to some ontological structure whereby the semantics of the data can be added and the relations between the data can be expressed. From representing the *syntax* (logical forms and symbol structures) and the *semantics* (meaning of symbols), there are pressures that the www should/could be moving toward *pragmatics*. The pragmatics, i.e. addressing also the context of using symbols, is what differentiates the pragmatic web from the mere semantic web. The emergence of the pragmatic web does not mean rejection or disappearance of the semantic web; many investigators assume that semantics will thrive as a function of pragmatics becoming more powerful. Pragmatic web is focused on developing tools, practices, and theories concerning why and how people use knowledge rather than mere addressing logical forms or symbolic meaning of information.

In the context of the pragmatic web, contextually specified information usage rather than mere search or transmission becomes the central concern. Toward that end, centralized solutions are giving space for co-development of services based on customer-provider negotiations, radical customization of products, and cultivation of long-term co-configuration of products within networks of producers, subcontractors and customers. The pragmatic web implies that the role of user communities in interpreting, sharing, applying, and creating knowledge becomes essential. Rather than simply assimilating already existing knowledge, user communities engage in active negotiation and interpretation of meaning grounded of their prevailing practices and epistemic objectives. Toward that end, communities adapt ontologies for their evolving epistemic needs and purposes rather than rely on standardized one.

Design and Methods

The study was exploratory in nature and it aimed at to give hints for defining needs for practice-oriented ontological modelling and ways of understanding ideas of semantic and pragmatic web for the KP-Lab. We overviewed some of the group’s data modelling methods and examined their knowledge practice with new data modelling technology. The data consisted of observing some meetings and seminars by the group, collecting group’s written compositions and documents of the new modelling methods and projects, and interviews of the group’s leader. The study was planned to be continued with a more intensive follow-up, but was cancelled because of the new emphases in the KP-Lab project.

Case

The “Adaptive Cognitive Systems” case is about cutting-edge technology-intensive knowledge practices within the field of adaptive informatics. The group investigated is the

Cognitive Systems Research Group that is a part of Adaptive Informatics Research Centre (national centre of excellence), the Department of Computer Science and Engineering, Helsinki University of Technology. The research group consists of around 20 members.

The mission of the group is to conduct research on artificial systems that combine perception, action, reasoning, learning and communication. The group is drawing upon biological, cognitive and social system approaches to analyzing and modeling cognition. By utilizing methods and techniques related to adaptive informatics and statistical machine learning, such as self-organizing maps, SOM, kinds of artificial neural networks (Honkela et al 2008) and independent component analysis. They develop automated learning algorithms for discovering and analyzing complex patterns and learn from large amounts of new data.

Innovations of using adaptive informatics that the research group is exploring are interesting for KP-Lab. The research themes include emergence of linguistic and cognitive features and structures, learning social interactions, learning translation systems within and between languages, and knowledge translation and innovation. Knowledge translation can be described as evidence-based translation of knowledge, e.g., knowledge dissemination, technology transfer, knowledge management, knowledge utilization, and synthesis of research results within a local or global context.

The strength of adaptive informatics is to build on the communally created, often not mutually compatible resources. Whereas the semantic web involves efforts of top-down knowledge structure and system design, adaptive informatics relies on self-organizing processes of technologies that dynamically adapt to evolving requirements of social practices. By utilizing methods and techniques such as the self-organizing map (SOM), automated learning algorithms for discovering and analyzing complex patterns have been developed to support unsupervised and continuous machine learning from large amounts of new data (Kohonen, 2001; Honkela, 2005). The SOM is dynamic and associative, and consists of elements that can be called adaptive prototypes. The adaptation process in the SOM is based on the principle that what already exists in the system also influences the learning result (Kohonen, 2001). When text documents like transcripts of interviews are analyzed with this method, with its emphasis on the grounded nature of knowledge, the SOM approach aligns well with the central epistemological presuppositions of traditional and revised grounded theory (Janasik et al, 2008). By relying on other kinds of adaptive technologies, it is also possible to simulate social practices (Lindqvist et al, 2007) and to support co-configuration of relationships between producers and users (see <http://www.cis.hut.fi/research/cog/pracsim/>).

The technology and how it is used - Pracsim-tool and Kulta-project

One application using adaptive informatics is *Pracsim* simulation. It is a good illustration about the groups' ideas on the use of technology, and how it is developed in close collaboration with customers. The system is modelling the basic concepts of a *practice theory* developed by prof. Pantzar in collaboration with his colleagues. The practice theory assumes three basic elements for modelling practices: material (materials, technologies and tangible, physical entities), image (domain of symbols and meanings), and skill (competence, know-how and techniques) (Lindqvist et al, 2007). The theory depicts complex, and rich phenomena and for that reason is an apt application domain for adaptive informatics. The technology aims at simulating complex social phenomena, that is, how different items depicted in the theory interact, and can be linked. A view from Pracsim is presented in Figure 1. The left hand side of the screen refers to the three different elements in the practice theory (and how they are grouped). The right hand side of the screen includes materials, a number of individuals, and how they have adopted a practice.

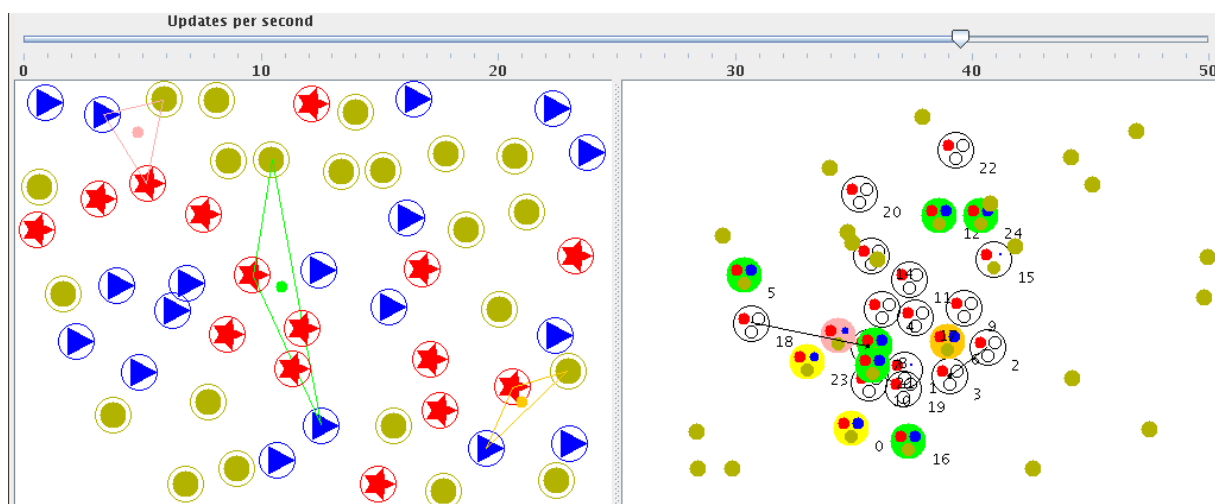


Figure 1: A screenshot of the Pracsim simulation (Lindqvist et al, 2007).

Pracsim has been developed and applied in a project called “Kulta” that aims at understanding, conceptualizing and anticipating the new consumer practices. To that end a computer system employing the visualization of Practice Theory was created. Kulta-project is a multidisciplinary project having participants from the university, national consumer research centre and companies. Kulta-project investigates possible emergent patterns of modelled practices that can provide insights to studying consumer practices and form a basis of further hypotheses. This technique is analogous to the research done using self-organized maps where the role of technology is to provide new representations that serves as a basis for reflection on the phenomena and collected data. According to this, in an interview the group leader stated:

“[o]ne of the problems with these ontologies and semantics is that they start from that external reality like they were escaped from the bottle, that is, that there is no kind of a material connection to the reality experienced” (group leader).

A central motivation is to deal with complex phenomena and data representing both individual and social levels of reality. The consumers for take active part in terms of adapting customer-intelligent products. This relies on the ideas of ‘Consumer 2.0’ that builds on active citizenship and community building instead of one-directional flow of products and services from enterprises to customers, which is central also to the KP-Lab ideas of participatory learning with technology.

Collaborative practice of the research group interacting with the technology

Another illustration of the technology merging with practices is ACS-groups seminar practice. A close look at group’s seminar practices revealed interesting new ways of using modelling technology to support collaboration and knowledge creation. In one particularly interesting meeting the group planned a new application for the adaptive informatics technology to be used for analyzing data from abstracts of an upcoming conference. The aim was to test how to collect data and use modelling technology. This test gave a good overview of how the use of adaptive informatics technology intertwined with collaboration and negotiations. The group used the SOM technology and SMS messages to chart and discover overlaps within the group's research topics. The people first listed up their research phenomena and methods. The creation of the concepts on the list was guided by the leader while everybody participated in the discussion of identifying common concepts for research phenomena and methods used by the researchers in the group. The created list was shown on the beamer for reference and further discussion and completion of the list. Research phenomena and methods were coded as numbers to be submitted for the survey using SMS. While others were answering, the group leader was making instructions for the answering, and formatting it to be

understandable also to those members of the group who were not present to be used as a template for future implementations of the survey method. SMS's were then sent to the phone of the person who was handling the modelling software. The messages were transferred via Bluetooth connection to a computer running the SOM program (MatLab) on university server. After the SOM analysis, the intermediate SOM results of the survey were shown on beamer. The final SOM result was then shown and there was a discussion on the interpretation of the map. The discussion concerned, for example, the validity of the meter and the subjectivity of answers on a 1-5 scale of relevance to each persons own research topics. The design of the survey was evaluated and possible future implementations of the method were discussed, especially in relation to the upcoming conference (as a networking possibility for researchers with other researchers' and groups' interests).

The example show how closely the use of modelling technology in this project is related to discussions and negotiations on the concepts and phenomena with participants, and how the whole setting and ensuing interpretations are done collaboratively. The aim was to give a *certain* kind of interpretation of the phenomena in question, which was not build on a fixed categorization. SOM suggested patters that would be unreachable with the prevailing technologies. However important the role of technology was, the role of participants was central in creating and interpreting the model.

Summary of findings – implications for KP-Lab development

The relation of practices and technology

The findings of the study are related to the understanding of the role of technology in relation to practices. The tools developed by the research group in question are specialized but they have a wider interest in conceptualizing the ideas related to the pragmatic and semantic technologies. The group itself is quite explicitly aiming at to find technology which is an alternative to (previous) ways of using semantic technology. The group develops technology to give flexible ways of capturing phenomena, which take human practices more into account.

The role of users in interpreting and modifying the information with technology is different from traditional ways of understanding the division between users and technology. The process is tailored from the start in close collaboration with the users, and the advantages foreseen have their basis on having flexible categorizations and adaptations for using the technology. The way of using adaptive informatics technology is closely connected to particular situational practices of having negotiations among partners in the phase of using the applications and in the phase of interpreting the analyses. It seems that this relationship is particularly dense in the use of adaptive informatics than in many other analysis and interpretation methods. This was demonstrated in the group's own use of the technology which had its basis on close negotiations on the concepts, methods, and interpretations concerning the data used. This negotiative character had clear counterparts in practices of the research group. Technology had an essential role in collaborative practice of developing ideas; especially supporting ways of externalizing ideas produced in face-to-face meetings.

Implications to KP-Lab development

The main purpose of the present case was to provide mirror material and ideas regarding how to integrate semantic web technologies with KP-Lab's emphasis on knowledge practices. Simultaneously it has provided access to knowledge practices, including direct links to data-exploration intensive knowledge practices critical in eScience. By interviewing, documenting, and analyzing projects being carried out by the group, the aim was to investigate state-of-the-art technologies going beyond the semantic web. The group investigated is developing new technology to capture things related to practices. There seems to be many similarities to the

aims of the KP-lab but also differences. KP-lab is building more on the ideas of semantic web (than on pragmatic web) but emphasizing the support for pragmatic use of this technology (see Deliverable 3.3 “A report on educational technologies and emerging web technologies in relation to dialogical approach to learning”).

KP-Lab project relies on an assumption that technology enhances learning only through transformed social practices. This aspect is missing in many discussions on semantic web. In our understanding the current efforts of constructing a KP-Lab Reference Model become even more important when the pragmatic elements are included in addition to semantic elements. In the settings with heterogeneous collaboration, the practices consist of multiple perspectives, aims and emphasis. Metadata of the practice elements would serve for negotiation between partners. An interesting possibility is to use metadata to describe the relations and problems between activity elements, or the reflective actions upon the elements, etc. Also, other data can be added to describe the activity. The strength of this kind of representation is that it allows the user to visually and verbally structure the activity.

Having explored the ‘idea-interface’ of semantic and pragmatic technology, we have come across to the questions ‘What are the pragmatic elements that the technology can support?’, or ‘What is the human activity that makes the technology pragmatic?’ For the first question it is reasonable to seek the answers from the features of the technology that are able to model the practices and thus support in developing the practices. This is the case, if the ontology of the technology allows tracing the practice related elements, i.e., modelling of the problem solving process in certain context. The second question can be approached from the interaction of humans and technology, i.e., the technology has features that are able to model certain critical elements of the data, on which the people can reflect on but also flexible change the features for the further modelling. The difference relies on the flexibility of the ontology and in the interaction between human and technology. In the first example the ontology is pre-given and unamended and the flow of information is from technology to human, whereas in the latter the ontology is changeable and there is interaction between technology and human.

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