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A Cooperative Design Method for SMEs to Adopt New Technologies for Knowledge Management: A Multiple Case Study

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Abstract: This paper presents cooperative design as method to address the needs of SMEs to gain sufficient knowledge about new technologies in order for them to decide about adoption for knowledge management. We developed and refined a cooperative design method iteratively over nine use cases. In each use case, the goal was to match the SME's knowledge management needs with offerings of new (to the SMEs) technologies. Where traditionally, innovation adoption and diffusion literature assume new knowledge to be transferred from knowledgeable stakeholders to less knowledgeable stakeholders, our method is built on cooperative design. In this, the relevant knowledge is constructed by the SMEs who wish to decide upon the adoption of novel technologies through the cooperative design process. The presented method is constituted of an analysis stage based on activity theory and a design stage based on paper prototyping and design workshops. In all nine cases, our method led to a good understanding a) of the domain by researchers – validated by the creation of meaningful first-version paper prototypes and b) of new technologies – validated by meaningful input to design and plausible assessment of technologies' benefit for the respective SME. Practitioners and researchers alike are invited to use the here documented tools to cooperatively match the domain needs of practitioners with the offerings of new technologies. The value of our work lies in providing a concrete implementation of the cooperative design paradigm that is based on an established theory (activity theory) for work analysis and established tools of cooperative design (paper prototypes and design workshops as media of communication); and a discussion based on nine heterogeneous use cases.

Keywords: Cooperative Design, Innovation in SMEs, Knowledge Management
Categories: M.0

1 Introduction

Knowledge management (KM) activities are relevant for all kinds of companies [North, 2011]; and information and communication technologies are used to support many of those activities. However, the transfer and adoption of innovative knowledge management technology in businesses and their value creating processes still present significant barriers. Especially for small and medium-sized enterprises (SMEs), barriers encompass lack of know-how, lack of resolutions for small SMEs, lack of experts and investment in short-term goals instead of long-term goals [Baptista et al., 2006, EU ICT Task Force, 2006; Arendt, 2008]. For SMEs there is a higher risk associated with an investment, which may be relatively higher w.r.t. their overall budget than for larger companies, and SMEs therefore have more limited opportunities to experiment and fail.
For knowledge management technologies in particular, SMEs are typically tightly woven into regional and national networks. In such cases, knowledge management is not only an issue internal to the organization but rather one that is spanning several other organizations, like research and development partners, customers and suppliers. These disadvantages are shared with so-called network companies, i.e. companies or associations that support a whole industry sector, a network of companies or professionals. Consequently, SMEs and network companies often lag behind with regard to employing novel technologies for knowledge management, as issues of decision-making and integration are complex. However, properly harnessed and leveraged knowledge is of crucial relevance for SMEs to stay competitive and outperform their rivals [Goh, 2002, Wong et al., 2004].

This paper describes a method and associated tools that allows decision-makers in SMEs to decide upon the suitability and subsequent adoption of novel technologies based on the principle of cooperative design [Greenbaum and Kyng, 1991a]. This means, that the knowledge necessary to decide upon adoption is created through design; and at the end of the decision-making process first concrete ideas and prototypes are already finished, thereby making the process resource-efficient for SMEs. New technologies hereby mean specifically “new to the SME”. We examine SMEs in different configurations of cooperation. Knowledge management technology refers to any ICT technology that can potentially improve knowledge processes with the intention to enhance value creation. The method and tools have been iteratively developed throughout nine case studies; and have been evaluated throughout this design process. Below we first give background on innovation diffusion in SMEs, cooperative design, and activity theory (Section 2); then describe our overall research approach and methodology (Section 3), the cooperative design method and tools (Section 4), describe one exemplary case in detail (Section 5), discuss method, tools, and overall results (Section 6), and summarize the paper in a concluding manner (Section 7).

2 Background: Cooperative Design for Innovation in SMEs

2.1 How SMEs adopt novel technologies

Adoption of novel knowledge, and in particular, novel technologies has been studied from many different disciplinary perspectives over the last decades, typically under names like knowledge transfer and innovation diffusion.

The challenge for SMEs to evaluate new technologies for their suitability to address the SME's needs can be seen as one of knowledge transfer. From this viewpoint, the SME learns from experts about new technologies to improve business performance (see e.g., [Van Wijk et al. 2008; Darr et al. 1995]). It would be typical for SMEs that knowledge transfer from external organisations is necessary for staying in business [Chen et al. 2006].

Different types of frameworks focusing on conventional knowledge transfer within and in-between organisations have been discussed in literature. These frameworks point at "soft" key factors like organisational prerequisites as well as different dimensions of knowledge that hinder or facilitate knowledge transfer [Goh, 2002; Bou-Llusar and Segarra-Ciprés, 2006)].

Innovation diffusion takes a more passive perspective on how innovations are adopted, mainly in terms of an informal horizontal process mediated by peers [Greenhalgh et al. 2004]. This literature often focuses on innovation in terms of its properties (e.g. how complex it is), and includes the readiness of organisations for adopting innovation. Specifically, absorptive capacity can be seen as the dynamic capability of organisations to acquire, assimilate, transform and exploit knowledge [Zahara and George, 2002], with the goal to integrate it into the organizations' existing knowledge base and to assimilate it into the organizations' daily working routines. Knowledge transfer, innovation diffusion, and absorptive capacity have in common that they see the innovation process as one of handing over new knowledge or new innovations in a linear process as if they were an object with certain properties.

In this paper, we suggest a perspective that is routed in literature about knowledge creation (e.g. [Nonaka and Takeuchi, 1995]) and organisational learning, where innovation diffusion is seen to involve integrating knowledge across disparate communities [Newell et al. 2000]. Here, innovation is understood as a comparatively long adaptation process in which the organisation adapts to challenges it faces by a collaborative effort to create new knowledge and practices.

While there exist numerous empirical studies for innovation diffusion of knowledge management systems (e.g. [Quaddus and Xu, 2005, Lin, 2013]), and notably some that take a knowledge creation perspective (e.g. [Newell et al. 2000]), there are far less propositions of how to practically design and implement such innovation adoption processes in practice, also confirmed by [Greenhalgh et al. 2004].

2.2 Cooperative Design as Approach to Innovation

In this section, we therefore introduce an alternative view that is in line with organisational learning and knowledge creation. We propose that in complex socio-technical systems a cooperative design process is more successful [Baxter and Sommerville, 2011].

Cooperative design processes for developing software, as well as solving more general problems (e.g., under the name design thinking) have grown in popularity during the last years as knowledge intensity has intensified and more collaborative modes of innovation have become common in industry [Sanders and Stappers, 2008].

A general goal of cooperative design is to increase the likelihood of usefully integrating new systems into a working environment [Kensing and Blomberg, 1998], by connecting those who are responsible for technology design and those having to live with the result. Thus, cooperative design was originally set up as the cooperation between designers and end-users [Bødker et al. 1995]. This lead also to a paradigm shift from designing products to designing for user's purposes [Sanders and Stappers, 2008]. The goal is to get a better understanding of relationships between work and technologies in order to ensure a better fit between newly developed technologies and the way people need to perform their working tasks. A variety of terms that mean very similar of things exist in literature, such as participatory design, co-creation or co-design. Participatory design attempts to actively involve all stakeholders (e.g. employees, managers, partners, customers or end users) in the design process to ensure that the results meet the individual as well as organisational needs [Kensing and Blomberg, 1998]. Participatory design often comes with the connotation that participation of users is also an emancipatory act, such that involving users as partners in design is not only practical (as they possess the unique competence of how they will need to use software) but also their right in the sense of being allowed to participate in deciding on how tools for their work and lives look like [Bødker et al. 1995]. Sanders and Stappers [Sanders and Stappers, 2008] define co-creation more widely as "*any act of collective creativity, i.e., creativity that is shared by two or more people*" while co-design, which is a specific instance of co-creation, is defined as "*collective creativity as it is applied across the whole span of a design process*". [Grønbæk et al. 1997] go one step further and suggest active user participation not only in the design process, but throughout the entire development process. The exceptional advantage of PD lies in the fact that it takes place neither in the user's nor in the developer's domain, but that it creates a hybrid in-between space that can make best use of attributes of both domains [Muller, 2003]. As a consequence, the change from a user-centered design approach ("user as subject") to a participatory design approach ("user as partner") [Sanders and Stappers, 2008] has also influenced the different intensities and forms of interaction in the cooperative design processes including the roles of all stakeholders. For example, the role of users can range from passive consumers (as before) to meta-designers, depending on their expertise in the domain and in design. Researchers often serve as facilitators that lead, guide or provide scaffolds during the design phase and mediate between users and designers, while designers will design the tools for non-designers and at the same time need to keep pace with new technologies, production processes and companies' contexts (ibid). A key characteristic of cooperative design approaches is that iterative learning processes take place that involve all stakeholders and support learning about the respective other domains and how-to best function in the desired cooperative design process [Sanders and Stappers, 2008, Greenbaum and Kyng, 1991b, Bødker et al. 1991, Bødker and Grønbæk, 1991]. For the purposes of the present work, a cooperative design approach is chosen to support innovation in SMEs, particularly making use of this characteristic of cooperative design activities requiring as well as

inducing learning of all stakeholders; and a concrete cooperative design method has been developed.

2.2.1 Tools Supporting the Cooperative Design Method

Typical stages of a cooperative design method encompass Analysis, Design/Implementation and Evaluation [Henry and Thorp, 2004].

For each stage mentioned above there exist tools that support to achieve the goals of each stage. For the analysis stage, we have developed a new tool using as background activity theory and that we will present in the next section. For the design/implementation as well as for the evaluation stage, we will shortly summarize existing tools and their corresponding backgrounds that we applied in this work.

Over time, various tools and methods were developed to facilitate cooperative design ranging from simple review and observation of existing material, technologies and processes over questionnaires and interviews to workshops with diverse participants and mock-ups [Kensing and Blomberg, 1998].

Mock-ups had been used in industrial design long before they also became a part of the process of designing computer systems [Westerlund, 2009]. In the mid-1990s, popular companies started adopting paper prototyping as part of their product development process [Snyder, 2003]. [Floyd 1984] considered "*prototyping as a component of software development methodology*" serving as an element for communication and feedback between the software developers and the users. This is also in line with [Ehn, 1988], who already emphasized that "design-by-doing" methods like mock-ups and prototypes are not only helpful tools for designers, but also allow the involvement of non-experts in the design process. Thus, design-by-doing became a primary activity in cooperative design [Bødker et al. 1991] as it is very important for users to somehow experience or envision how the planned tool will function during work [Bødker and Grønbæk, 1991]. The aim of a cooperative prototyping [Bødker and Grønbæk, 1991] is therefore to instantiate a design process where designers and users are working actively and creatively together on a prototype and offer especially users to try it out and play around. And as [Albinsson et al. 2008] already argued, it is crucial to let users develop their own ideas to achieve a practically useful design. [Snyder 2003] summed up the ubiquitous applications of paper prototyping for "*brainstorming, designing, creating, testing, and communicating user interfaces*" and [Pfister and Eppler 2012] confirmed the support especially of sketching for knowledge creation, sharing, and documentation.

In the evaluation stage, workshops are often used in participatory and cooperative design processes as means of bringing together diverse stakeholders (e.g. users, developers) for communication, creation of shared knowledge, commitment to shared goals as well as discussion of needs and jointly making solutions [Buur and Bødker, 2000, Muller, 2003, Steen et al., 2011]. They also provide the opportunity for future users to evaluate prototypes consisting of various forms, which leads to developers' better understanding of user's practice as well as to ideas for improving the design [Grønbæk et al. 1997]. This meeting of different competencies is crucial for tailoring the design to user's actual needs [Ehn, 1988] and ensure better acceptance of the final solution [Beaudouin-Lafon and Mackay, 2003].

2.3 Activity Theory

In this section we very briefly review Activity Theory, which we use as basis for a significant tool in our proposed cooperative design method, the activity system (AS) table that supports work analysis. We review this theory here, in order to fully set up the theoretical basis of the present paper; the relevance of activity theory lies in the fact that it supports the analysis phase of cooperative design.

Activity theory is a descriptive theoretical framework that proposes a terminology for understanding goal-directed activities. There is much literature available on activity theory; our description of activity theory below relies most strongly on [Engeström, 1987, Engeström, 1999, Kaptelinin, 1996a; Kaptelinin, 1996b; Kuutti, 1991; Nardi, 1996a; Nardi, 1996b; Engeström, 2001].

Activity theory considers activities as overarching human endeavours. These are directed towards an object. Each activity has a subject – the person(s), units, SMEs or organisations who act; and an object, which is created, manipulated, and worked towards. Activity theory establishes three hierarchical levels of analysis: Activities are composed of finer-granular actions. Actions are short-lived and goal directed, while in contrast activities are durable and object-oriented [Engeström, 2000]. Furthermore, actions are composed of operations, such that an operation is a concrete routine for implementing an action. Operations are extremely content-specific. In the present work, we have used the level of activities and objects to analyse and design for work.

Activities are mediated by artefacts in the sense of tools that are used to carry out the activity. Depending on the used artefacts, the characteristics of the activity change. An artefact can be a concept, written document, or physical object that supports and shapes the activity; it means equally Pythagoras' theorem or a hammer – both are tools that help the subject of an activity; and both are man-made in the sense that the subject has the artefact only available because of the cultural heritage into which the subject is embedded.

In a collaborative activity, the subject of the activity is embedded into a community of subjects who share an object – without this shared object(ive), there is no community. Rules mediate the structure of collaboration between the subject and the community; and division of labour defines how the community shares the overall burden of actually achieving its objective, and manipulating the object.

Because of activity theory's emphasis on mediation, both of activity and collaboration, it has been widely used as an analytical framework for discussing information and communication technologies for knowledge management [Collins et al. 2002, Hasan and Gould, 2003, Meyers, 2007, Ben Moussa, 2009a] or organisational learning [Kuutti and Virkkunen, 1995]. Knowledge elicitation methods in these papers typically consist of observations and/or interviews with stakeholders.

An important recent focus in activity theory research is on "tensions" in activity systems (AS) that come out of work analysis. According to Collins et al. [Collins et al. 2002], these tensions can occur i) within single activity system elements (e.g. rules or tools), ii) between different activity system elements (subject - rule) and iii) between different activity systems. [Ben Moussa 2009a] focussed on the identification of tensions between different activity system elements, such as <Subjects-Tools-Object>, <Subjects-Rules-Community>, or <Community-Division of labour-Object>.

3 Research Approach

The core challenge we address in this work is to enable SMEs to assess new information and communication technologies that may address their needs for knowledge management solutions. This intends also to use the SMEs' resources efficiently. Our approach aims to create sufficient understanding of new (to the SMEs) technologies for such assessment by using a cooperative design approach in which researchers and SMEs cooperate in designing ICT based new technologies.

We therefore have developed a cooperative design method, and concrete tools for cooperative design. The cooperative design method and tools should allow stakeholders (in this case: researchers) knowledgeable about novel technologies, and SMEs interested in deciding about novel technologies with the purpose of deciding upon adopting these in their knowledge management, to use cooperative design to in parallel a) take that decision, and b) progress already towards creating a meaningful design. The goal of the cooperative design method and tools was not necessarily to create designs that would already be mature enough for implementation.

The method and tools have been iteratively developed based on theory (cooperative design for the overall method, and activity theory specifically for work analysis), and have been applied in nine use cases. At every use case, we evaluated whether participating decision-makers of SMEs generated a) plausible insights and assessments of technologies' benefit for the respective and b) meaningful designs. Thereby, we wanted to measure whether our dual goal, to support deciding on adoption, at the same time as progressing towards concretising implementation, had been met.

3.1 Overview of Industry Cases

The proposed methodological framework was applied in nine cases involving a very heterogeneous set of SMEs from Austria, Estonia and Norway. The Austrian SMEs were part of a small project dealing with knowledge management and eBusiness, while the Estonian and Norwegian SMEs were participants in an Estonian project. All these institutions deal with similar challenges regarding knowledge management and organisational learning. Although knowledge management is mostly part of their core business, it is often not explicitly funded in terms of dedicated personnel. Thus, all institutions showed interest in making advancements with regard to knowledge transfer in their organisations using technology support. Table 1 summarizes shortly their provision of service and their aim of the KM initiative taken. The companies vary in terms of size and sector, and with regard to how they were embedded in regional networks. The last case of managed regional clusters was included to extend our analysis to a situation of highly interrelated SMEs cooperating in regional innovation networks. While in all other cases, decision makers of the respective SMEs were interviewed, in the last case we focused on interviews with managers of the cluster initiative.

SME/ Network	Provision of Services	Aim of KM initiative
Austria		
Fertilisation Clinic	Clinic that offer treatments to turn couples into parents.	Improvement of knowledge management w.r.t. their currently very distributed data management.
Company N	Telecommunication Company dealing with network and security issues, collaboration and communication as well as data center and virtualization.	Establishment of an improved internal information and knowledge transfer between all departments and locations.
Company K	Software company mainly dealing with web-design, digital marketing and customer relationship management.	Collecting new ideas w.r.t. KM to improve their own performance.
Company D	Software company dealing with digital marketing including websites, web-shops, newsletter, or social media marketing.	Improve the usage and evaluation of their already collected and stored data w.r.t. data-driven business.
Company Y	Software company for web usability and design.	Collecting new ideas for optimizing company intern KM processes.
Estonia		
Professional Services Company	Professional services company dealing with knowledge management as the key part of their strategy.	Increasing organizational efficiency through facilitating knowledge reuse
Regional Hospital	Biggest hospital in the country and coordinates the network of regional hospitals and has connections with vocational training schools.	Improvement of cross-institutional knowledge-gap discovery and learning programs' related interventions in vocational schools and in in-service training in hospitals.
Road Construction Admini-stration	The national Road Administration coordinates the units of road-construction (archiving road probes), car-inspection car exams (archiving car inspection and car exam videos), and public transportation (deals with animal track videos on roads). These units maintain information that could be used for knowledge discovery to develop learning opportunities.	Improvement of information (documented visual and video-evidences) re-usage for the purpose of organizational learning, discovering problem topics and issues, using evidences from relevant cases in training.
Norway		
Managed regional	They consist of national innovation center, regional innovation clusters,	Improvement of learning and innovation support services in the knowledge based

clusters	ICT cluster, agriculture and food, oil- and tourism clusters.	ecosystem consisting cluster managing bodies, cluster organizations and organizations (SMEs, R&D and Academia) within managed clusters

Table 1: Participating SMEs and network companies

4 Cooperative Design Method

The cooperative design method consists of an analysis, a design, and an evaluation phase as depicted in Figure 1 including the application of corresponding tools per phase. The analysis phase consisted of interviews with key people in the organisation followed by the development of activity system (AS) tables and activity system (AS) trajectories to analyse opportunities and constraints of current practices. As a second step, we consider paper prototyping and design workshops as suitable instruments for cooperative design because they allow for prototyping and experimenting with new technologies without a large investment. All tools are described in the subsections below.

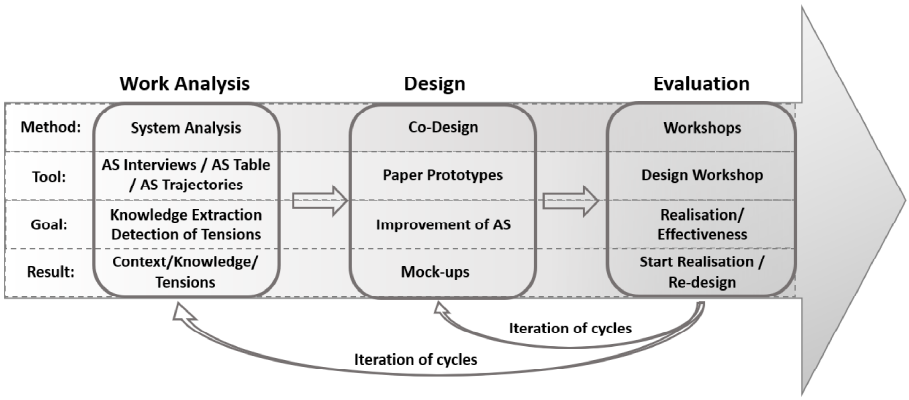

Figure 1: Cooperative Design Process

4.1 Work Analysis

The purpose of the analysis phase is to gain an understanding of the current practices in the organisation so that transferred knowledge/technology/innovation can be put to productive use. We need to consider the target organisations as complex systems consisting of several different levels of agency that need to be brought into coordination to produce collective activity. According to [Kuutti and Virkkunen 1995], organisational learning cannot be studied by reducing the scope of analysis to single elements, but that a minimum meaningful system as a whole (the company embedded in its wider environment) should be taken as the unit of analysis and intervention.

4.1.1 Knowledge Elicitation: Activity System Interviews

The activity system (AS) interviews were structured interviews aiming at i) getting an overview of the SMEs or network companies, ii) extracting detailed insights into used knowledge management processes and iii) detecting first impressions of possible tensions, design opportunities and constraints for knowledge management.

In Austria, we have conducted altogether 10 interviews in 4 different companies. The interview participants (5 females, 5 males) consisted of 4 CEO's, a creative director, a head of finances and HR, 2 project managers, a web developer and a nurse. All interviews were recorded (with the consent of the interviewee), transcribed and analysed. The interviews took place at the companies' site so that the researchers got their own individual impressions about them. The interviews were conducted either individually or in small groups to establish a conversational atmosphere that allows giving honest, unbiased opinions representing diverse viewpoints. The interviews gathered general information about the company (e.g. How large is your company? What departments are there in your company? What professions are there in your company?) and topic specific information with regard to knowledge management and organisational learning. The topic related questions were structured according to three levels (agent, organisational and cross-organisational) and took into account the elements of the activity system (e.g. Agent level: How does your official knowledge management strategy look like? Organisational/Cross-organisational level: Which technological tools do you use for your knowledge management in relation with external partners or superior institutions? What happens with information from external stakeholders or superior institutions - how are they managed, maintained and integrated into your knowledge technologies?)

Example from Company N: employees were asked about their expectations to this project with regard to KM: "*For me it would be important to learn about the issue how can I set up knowledge management, how can I build up communication for by now 7 sites that works, that is transparent and where as many as possible feel motivated to feed something into the system. And how can I manage to hit the right target groups with this information, what tools are there and how can a process be started that guarantees that all 7 sites are uniformly, homogeneously supplied with knowledge.*"[1] (Translations from German done by the authors).

4.1.2 Activity System Table

The AS table is based on activity systems proposed by [Engeström 1987] and [Cole and Engeström 1993]. It was used to document key elements of the analysis, and it was developed and refined during its application (see Table 3).

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[1] German original text: "*Mir wäre es wichtig, dass wir was dazulernen über das Thema, wie kann ich Wissensmanagement einerseits aufsetzen, wie kann ich bei mittlerweile 7 Standorten Kommunikation aufbauen, die funktioniert, die transparent ist, wo sich möglichst viele einerseits motiviert fühlen, in das System was hineinzuschaufeln, und wie kann ich es aber auch schaffen, die richtigen Zielgruppen mit diesen Informationen zu treffen, welche Tools gibt es dazu und wie kann ein Prozess in Gang gebracht werden, der garantiert, dass alle 7 Standorte gleichmäßig, homogen mit Wissen versorgt werden.*"

The columns of the table encompass agent, organisational and cross-organisational level. The rows of AS table consist of subject, community, roles, rules, tools and objects. We adapted the original AS table iteratively to our needs by including elements necessary for eliciting information with regard to knowledge management and learning. Particularly we added the distinction between informal and formal community aspects (e.g. modes and types of engagement, structures of interaction), roles (e.g. positions, tasks, trust and credibility) and rules (e.g. norms, permissions, accesses, incentives) because KM solutions should build on top of existing informal practices, roles and rules to create better ownership of new formal digital practices. The tools section followed the same dichotomy of formal and informal tools, where formal tools corresponds to tools (e.g. software, trainings, digital device, pre-defined vocabulary, information systems, taxonomies) that are prescribed to be used within the unit, SME or organisation, and informal tools (e.g. personal software, personal trainings, blog entries, notes on papers, personal bookmarks) that are chosen by the individual. The objects subsection particularly focused on learning- and work-related goals, since our focus for innovation design targets knowledge management and organisational learning.

During the mapping process (mapping the interview results into the AS table), we came up with guidelines defining what to map in each AS table cell (see Table 3).

4.1.3 Representation of Interview Results in AS Table

All interview results conducted per case were mapped into one AS table. This allowed us to detect tensions within or between different levels of the AS within the SME or their network, and to formatively evaluate the technology intervention needs, design opportunities and constraints with regard to tensions. The mapping process itself led to the development of new relevant aspects, for example, how activities are related to roles, rules and objects or how the used tools are related to the companies' goals.

Example of the fertilisation clinic: New clinic employees sometimes make some paper-based notes on post-its (e.g. some procedures, medication or information from colleagues). However, the goal of the company is not to leave notes lying around. From the clinic CEO we know, that everything needs to be digitalized, thus tensions may occur between staff members and the clinic superiors (see Table 2).

Activity System Components		**AGENT LEVEL**
COMMUNITY people as mediators of activities	INFORMAL NETWORK	Observation of colleagues doing their jobs and to learn from them Peer support (colleagues to ask) for new employees
TOOLS as mediators of activities	INFORMAL TOOLS	Personal paper notes
OBJECTS Goals	LEARNING GOALS	Education of employees: not to leave notes lying around; align monitors so others can't look at it, don't use paper-based notes

Table 2: Activity system table of the fertilization clinic

Activity system components		**AGENT LEVEL**	**ORGANISATION LEVEL**	**CROSS-ORGANISATIONAL LEVEL**
SUBJECT(S)	AGENTS WITH DIFFERENT LEVEL OF GRANULARITY	Stakeholder types (staff, customers, trainers, enablers etc.	Units in organisation	SMEs, organisations (business, academic, political)
COMMUNITY people as mediators of activities	INFORMAL NETWORK (S)	Personal networks (mode, structure)	Informal organisational networks (mode, structure)	Informal cross-organisational networks (mode, structure)
	FORMAL NETWORK (S)	Formally required communication channels and chains (mode & structure)	Formal networks (mode, structure)	Unmanaged cluster or formal cross-organisational network. Managed cluster (mode & structure)
ROLES Roles divide tasks Activities done in a certain role	INFORMAL ROLES	Status (expertise/competences, see if there are roles of novices, experts) trustworthiness/credibility), informally taken tasks etc.	Informal statuses of units, informal roles of units to perform tasks	Irregular, emergent, needs-based, (competitive, commensalism) roles and tasks
	FORMAL ROLES	Work positions, work tasks, enabler roles.	Official hierarchy (horizontal, vertical) in roles and tasks Normative fixed task-chains	Temporal, project-based roles and tasks. Permanent, regulated, service-based synergetic (value-chains, service-chains, motivation schemas etc.) roles and tasks. Enabler and coordinator roles.
RULES Rules coordinate, regulate, prompt tasks, restrict/permit roles Activities are done as formal/informal practices	INFORMAL RULES	Informal rules (accepted behaviours, work-modes, motivation mechanisms) between stakeholders.	Informal rules (accepted behaviours, work-modes, motivation mechanisms) between units.	Informal rules (accepted behaviours, work-modes, motivation mechanisms) among organisations
	FORMAL RULES	Formal rules (norms, permissions/restrictions, regulations, incentives for BYOD, user-generated content and informal learning), access/permissions to stakeholder roles.	Formal rules (norms, permissions/restrictions, regulations, incentives), access/permissions to units	Formal rules (norms, permissions/restrictions, regulations, incentives), access/permissions to organisations
TOOLS as mediators of activities	INFORMAL TOOLS	Personal software, training for personal software/systems, acquiring software. Personal devices, training for devices. Informal artefacts (QA comments	Communication and collaboration tools (Skype, Online meeting tools, …) used beyond the prescribed organisation tools.	Communication and collaboration tools (Skype, Online meeting tools, …) used beyond the prescribed cross-organisation tools.

		in forum, personal reflections in blogs, docs and papers in personal folder, collections of bookmarks, competence profiles, contact lists, shared docs and calendars etc.) Information system types (domain knowledge, competences, cases, people whom I know etc.)		
	FORMAL TOOLS	Bottom up tagging and top-down vocabularies, taxonomies, ontologies in use of people. Information system types (domain knowledge, competences, cases, etc.)	Organisationally required/used software, systems, training modes, acquiring software For what is software used. Organisationally required/used devices, training modes Types of artefacts (shared databases and repositories, official organisationally shared calendars, google docs or spreadsheets etc.) Bottom up and top-down vocabularies, taxonomies, ontologies in use of organisational system, maturing of vocabularies, taxonomies, ontologies Information chains, accumulated, associated knowledge structures (procedure descriptions, cases)	Cross-organisationally used systems, shared training modes, acquiring software For what is software used. Common devices (and usage habits) across organisations, shared training modes Types of artefacts (procedure descriptions, cases, norms, expert commissions etc.) Bottom up and top-down vocabularies, taxonomies, ontologies in use of cross-organisational systems, maturing of vocabularies, taxonomies, ontologies Information chains, shared knowledge structures
OBJECTS Goals	LEARNING GOALS	Person's learning goals Highlight problem issues.	Informal learning at organisation Highlight problem issues.	Cross-organisational informal learning Highlight problem issues.
	WORK-RELATED GOALS (at separate lines)	Person's work goals	Organisation's goals (data management, knowledge exchange etc.)	Different organisation's goals, competitive edge etc. Common goals (marketing, training, developing innovation etc.), synergy

Table 3: Activity System Table (final version)

4.1.4 Identifying Design Opportunities and Constraints

[Hasan and Gould 2003] suggested a temporal representation of activity, emphasising the progress of an activity and its outcome. Based on their suggestion we developed a graphical representation of activity system tables, called activity system trajectories (AS trajectories), focussing on design opportunities and constraints arising at each level of the activity system. This representation is the link between the analysis and the design stage because it depicts several activities as the trajectories of knowledge transition/transformation between different organisational levels of the activity system [Engeström et al., 1999, Hasan and Gould, 2003]. Such trajectories across different levels can be used for modelling the designs for knowledge management and organisational learning as systemic KM solutions and describing how the value can be added to organisational knowledge along these trajectories [Zott and Amitt, 2010]. The AS trajectories put the activity into the center together with design opportunities and constraints (see Figure 2a, left). The subject is the initiator of the activity while the activity influences the object and the technology represents the tool used for the activity. AS trajectories are helpful for getting an overview of the planned innovation.

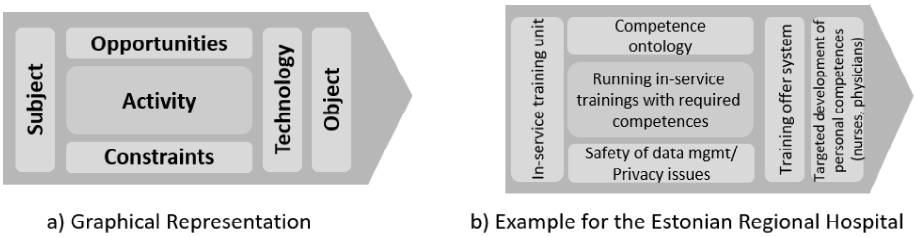

Figure 2: Graphical representation for depicting trajectories across activity systems.

Example of the Regional Hospital Estonia (see Figure 2b, right): *The hospital's in-service training unit (subject) provides in-service training for competences (activity) for promoting the lifelong development of nurses (objects). This training could be supported by a competence-based training offer system together with the portfolio-based personal competence management, which saves the competences a nurse has gained into personal profiles. Applying the nurses' competence ontology (opportunity) in mapping trainings and personal qualifications provides an innovation in managing workplace learning. Storing the taken training per nurse raises the data management and privacy concerns (constraints) since the safety of the personal qualification data should be guaranteed, while allowing making overviews of the competence gaps and training needs in different hospitals.*

4.2 Design

The purpose of the design phase is to use the gained understanding of the current practices in the cases for developing paper prototypes. Paper prototypes are ideal for prototyping and experimenting with new technologies and tools and combine tailor-made solutions to resolve the detected tension and to improve the activity systems without the need of real implementations and thus the need of large investments.

4.2.1 Paper Prototyping

The goal of the paper prototypes is to present possible knowledge management and organisational learning solutions aiming at resolving the detected tension and improving the activity systems. As input for the development of the paper prototypes serve both the developed trajectories of the activity systems and ongoing discussions via email or phone with the SMEs and network companies.

The first paper prototypes sketch the emerging ideas, which allow easily considering real-world scenarios and actual needs of the SMEs or network companies. Contextualisation, by incorporating screenshots or images of technologies already used within the SMEs or network companies, plays a crucial role with regard to the user acceptance.

Example from Company N (see Figure 3): *We developed a handful of technology paper prototypes addressing their challenge of how to distribute knowledge homogeneously throughout the whole company and how to transfer the right information to the right target persons. Therefore, we designed a system similar to a forum with many options for individualisation: to subscribe to keywords, topics, communication channels, events, departments etc., to choose between diverse notification settings and to enter events into a shared calendar*.

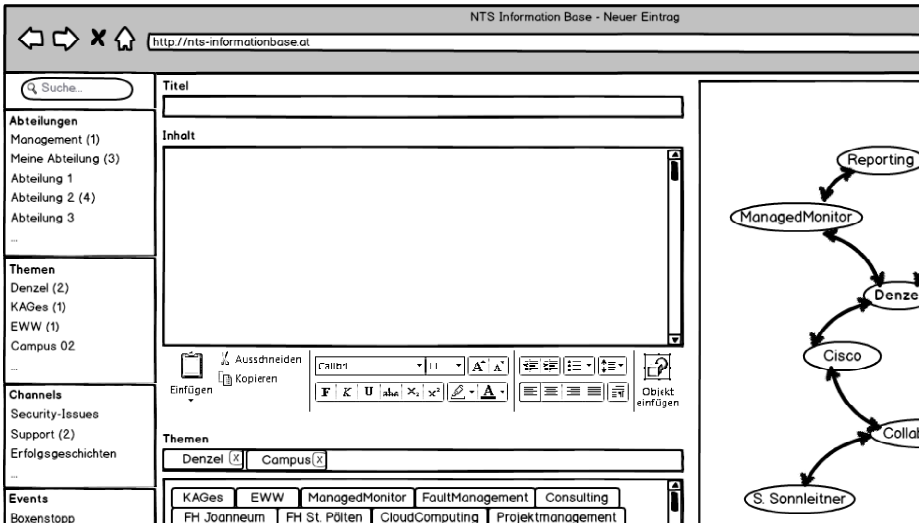

Figure 3: Paper prototype for Company N use case

4.3 Evaluation

The evaluation took place in form of design workshops. The goal was to assess a) whether researchers could gain sufficient domain understanding in the analysis stage in order to create meaningful first-version paper prototypes and b) whether SMEs could gain sufficient understanding of new technologies in order to assess technologies' benefit for the respective SME.

4.3.1 Design Workshop

The goal of the design workshops was to find out a) if the developed paper prototypes fulfil the SMEs needs, b) if they would be worth being realised and b) how they would influence the originally created AS table and the tensions detected at first.
The design workshops were located at the SMEs or company networks site. The paper prototypes were presented to the workshop participants. Additionally, prototypes developed for other SMEs or network companies were used to enrich the ongoing discussions with new input. Feedback and additional ideas of the participants were collected to refine the prototypes afterwards until they sufficiently meet the SMEs' key requirements [Fessl et al. 2015]. The discussions included also if and how an implementation of the prototype could be instantiated. The actual impact of new/adapted tools suggested in the prototypes was not evaluated by means of really implementing and introducing them to the SMEs and network companies (yet).

5 Case Company K

Company K is a software company dealing with web-design, digital marketing and customer relationship management. The company's focus lies on its self-developed customer relationship management tool as well as on the design, creation and marketing of tailored web presences and web shops. The case study has been previously described in [Fessl et al. 2015] and its description is extended here with a focus on the process. Company K was selected as showcase, because their setting and challenges serve as representative for all other SMEs' mentioned in this work. Furthermore, by using their self-developed customer relationship management (CRM) tool we can outline a striking picture on how to apply our cooperative design method.

5.1 Activity System Interviews for Knowledge Elicitation

The CEO and two employees with different responsibilities and experience levels took part in the interviews. The interview results provide insights about how the company addresses its knowledge management, including storage and maintenance of data as well as information retrieval issues and the technological infrastructure used. The employees use their laptops and computers to store data belonging to projects. Additionally, they use cloud storage systems (e.g. Dropbox, Google Drive) for data, which is not highly sensitive. The company-specific characteristic of their knowledge management lies in using their self-developed customer relationship management (CRM) tool, which is also their core product. With this tool company K manages all customer and project administration and the corresponding data (contacts, communication artefacts, tasks etc.).

5.2 Activity System Tables as Representations of Work

The interview results of company K were mapped into the AS table. Although not all available fields could be filled in, we derived enough insights for detecting tensions (see Table 4): The tension emerged between the tool (software) and object goals (work-related goals). The employees use their own CRM tool as main instrument for their knowledge and data management. All data is structured along customers and

associated projects, including tasks, contacts or other corresponding categories, which makes retrieval of such information easy later on. General programming solutions like code changes, templates etc. are not inserted in the system, even though they are regularly needed and used in their software development. Although there exists a wiki, where such general knowledge should be inserted in, this wiki is hardly used. On the one hand, the employees want to perform all working tasks for their customers in time and avoid additional tasks enhancing their workload. On the other hand, the management does not mandatorily ask to insert code snippets into the wiki. Thus, the work-related goal of the company to build up a knowledge base with general programming solutions has not been achieved up to now.

Activity System Components		**Agent Level**	**Organisational Level**
TOOLS as mediators of activities	FORMAL TOOLS	Self-developed CRM tool Wiki (for programming examples) not used Comments, ToDos, emails, documents, notes, contacts etc. shared in CRM tool, accounting docs, licences, company founding docs CRM containing all information about projects, contacts, products, etc. -> project leader receives automatic emails about new data in his/her project	Self-developed CRM tool; Wiki (for programming examples) hardly used Comments, ToDos, emails, documents, notes, contacts etc. shared in CRM tool CRM containing all information about projects, contacts, products etc.
OBJECTS Goals	WORK-RELATED GOALS	Perform all working tasks in time	Build knowledge base/forum with general knowledge/programming solutions

Table 4: Snippet from the AS table of company K relevant for identifying one tension

5.3 Visual Trajectories of Activities as Representations of Work at the Intersection between Analysis and Design

The tensions extracted from the filled-in AS table were used as input for revealing design opportunities and constraints while drawing visual overview activity system trajectories. The tensions discovered for company K focussed on the storing and reusing of code-snippets. Using these tensions as starting point, we developed AS

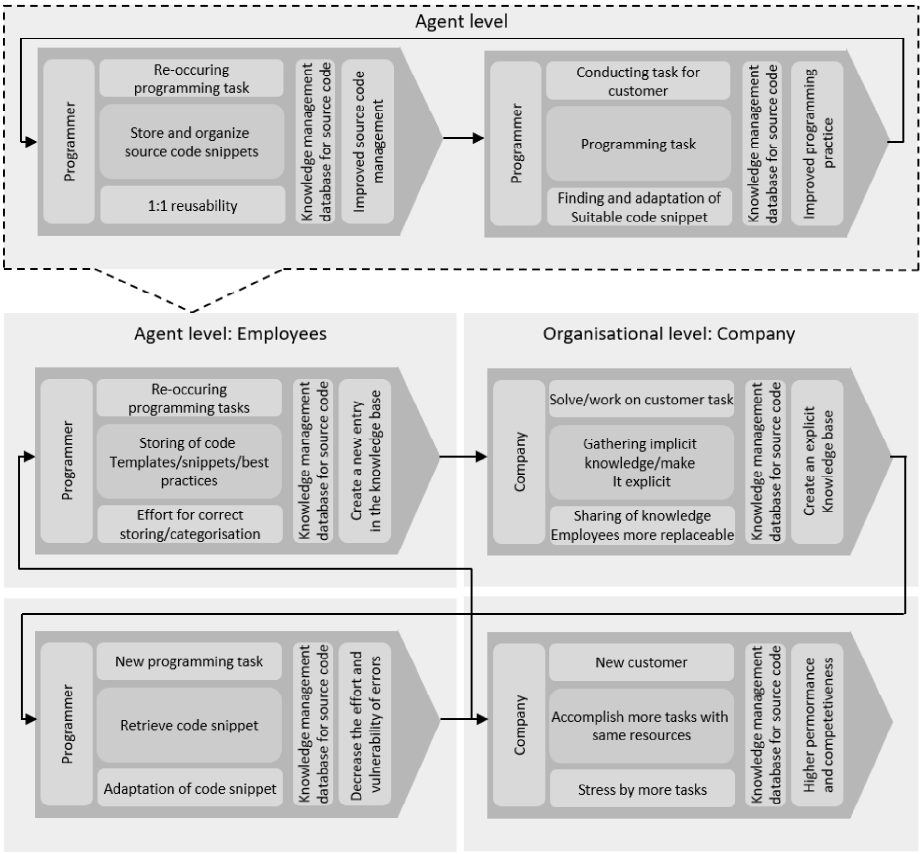

Figure 4: Activity System trajectories depicting trajectories across different levels of company K

trajectories on an agent level and across different levels as illustrated in Figure 4. On the agent level (Figure 4, top), we depicted the "storing and organizing of source code snippets" as activity. In this case, we understand activity as an overarching maintenance activity of all source code produced and not as a single action of storing one line of code snippet in the database. The activity is initiated by the programmer and results in the improvement of the source code management. This affects the activity of "programming", because it can enhance and improve the individual programming practice. As this influence is not restricted to the agent level, Figure 4 (bottom) illuminates possible influences across different organisational levels. From the employee's point of view, the intelligent storage and re-usage of code snippets can facilitate working tasks and improve the work performance (e.g. quicker programming solutions for similar tasks). Furthermore, the company would be less dependent on employees' implicit knowledge, needing fewer resources for certain tasks and as a consequence raise its competitive advantage towards other companies.

5.4 Paper Prototypes as Representations of the Potential Role of New Technologies in an SME

Following these AS trajectories, paper prototypes were developed and discussed with company K. The prototypes illustrate the integration of a forum into their CRM tool, which allows a simple storage of general knowledge from any place in the CRM. This forum can be enhanced providing pre-defined tags relevant for storing source code snippets (e.g. HTML 5, PHP). Using such tags as a structuring entity allows users to easily retrieve existing code snippets according to the attached tag.

The first paper prototypes were very positively perceived ("*The mock-ups were processed so well that they could directly be handed over to a developer*"[2]) by company K's employees. They were only slightly further extended to fulfil specific wishes and requirements and they already started to discuss on how to implement the prototype in their working environment.

Finally, the content of the original AS table was revised using the final prototypes as reference point. The content-based analysis focused on all aspects of the company's activity system, which would be influenced by the implementation of the suggested prototypes. The relevant components of the activity system were identified and adapted accordingly and resulted in an updated version of the AS table for each company. This illustrated how the proposed innovation would change the initial activity system.

6 Discussion of the Cooperative Design Method

We developed and refined a cooperative design method iteratively over nine use cases. The cooperative design paradigm we used is based on activity theory and we adapted, developed and applied tools for cooperative design consisting of interviews, activity system tables, activity system trajectories, paper prototypes and a design workshop.

The development of the activity system table progressed in parallel to the development of the interview guidelines. The interviews are guided by the AS tables and suggest making questions related to the different levels of the activity system (agent, organisational and cross-organisational level) including formal as well as informal components. Interviews need to be tailored to the AS approach so that the results can be holistically mapped into the common activity system table. The questions need to point at certain technological tools as system mediators as well as work processes (e.g. roles, rules). Asking for example participants of Company K to enumerate all used system mediators made the participants aware of their existence, why they were used or not used and for which purpose. While the participants mostly talked about their CRM, the wiki for storing code snippets in Company K was only marginally mentioned, but the general idea of it positively emphasized. This was one of the core issues for detecting corresponding tensions.

In parallel to the interviews, the AS tables were tested and iteratively improved in different contexts - in organisational and network organisation settings. The particular

[2] German original text: "*Die Mock-ups waren so gut aufbereitet, dass wir diese direkt einer Entwicklerin übergeben können.*"

difficulties were discovered in mapping the activities from interviews. We found that activities are described from role-driven (status, tasks, work positions, value- or service chains, time-related roles), rule-driven (accepted behaviours, work-modes, regulations, norms, permissions/restrictions, motivation mechanisms) and objective-driven (learning objectives, business objectives) perspectives. The AS table as a tool proved its value for structuring the information gathered by means of AS elements, which facilitated the identification of tensions. In the case of Company K, the entries of AS table revealed the contradiction between the work-related goals (build a knowledge base) and the software (hardly used wiki for storing code snippets).

Each tension discovered within the AS table can be mapped to one or more activities. The main innovation is creating the trajectories using a unified graphical visualization representing the transition paths between agents', organisational and cross-organisational levels of the activity systems related to the use case. Such AS trajectories can depict the stakeholders, the organisational knowledge management and workplace learning from the systemic point of view, indicating the knowledge accumulation, maturing and organisational learning loops for establishing organisational knowledge management and learning with technologies. Using these AS trajectories presented in Figure 2b for the Estonian Regional Hospital (agent level only) and Figure 4 for Company K (agent and organisational level) presents the transition paths for agents as well as agents and organisation. This sophisticated visualisation shows in an easy-to-understandable way how each of the addressed levels influence each other for example how the storage of code-snippets would positively influence the whole organisation.

Finally, the paper prototypes resulted in concrete tools for improving the SMEs' or network companies' knowledge management and organisational learning. In Company K, this took place by suggesting the forum extension of the already work-integrated CRM tool.

To sum up: we could show that our cooperative design method and the developed tools, which we applied in nine use cases, led to a good understanding a) of the domain by researchers – validated by the creation of meaningful first-version paper prototypes and b) of new technologies – validated by meaningful input to design and plausible assessment of technologies' benefit for the respective SME. Furthermore, we could show that the overall cooperative design method is an efficient way of teaching sufficient knowledge for SMEs to decide upon adoption, because at the same time knowledge is constructed and first ideas in form of paper prototypes are already created and can be evaluated according to their usefulness. However, in what way and to what extent innovative changes would actually manifest in real-world application, to which degree the created prototypes really solve the detected tension and which new tensions these might cause is still open to explore.

7 Conclusion

In this paper, we presented an iterative cooperative design method for matching SME's and company networks' knowledge management needs with offerings of innovative knowledge management technologies. Rather than seeing the innovation process as a process in which new knowledge or new technologies are "handed over", our innovation process was designed as an iterative cooperative design in which, as

iteratively stakeholders decided to move forward with design when it still made sense to them, analysis and design were gradually improved in terms of increasing granularity. The method is built on activity theory for the work analysis stage, on paper prototyping for the design stage and workshops for the evaluation stage. The tools have been iteratively refined and validated in nine use cases, where validation is based on the creation of meaningful paper prototypes by researchers and plausible assessments of technological benefits of taking up novel technologies by participating decision-makers from SMEs.

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