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# Analyzing Knowledge Flows as a Prerequisite to Improve Systems Development Practice

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# ANALYSING KNOWLEDGE FLOWS AS A PREREQUISITE TO IMPROVE SYSTEMS DEVELOPMENT PRACTICE

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## Abstract

*Knowledge is a key parameter for a modern company's survival. The ability to continuously become better at producing services relies on the organisation's abilities to develop and utilise the intellectual competences of its employees. Systems and software development organisations are no exception here. In this paper we present the concept of knowledge flow and an accompanying mapping technique to analyze knowledge management related issues as a prerequisite to improving systems development practice. Developed in an action research project, we demonstrate the benefits of the concept and the technique in a concrete case and point to further research and application challenges.*

*Keywords: Systems Development Practice, Software Process Improvement, Knowledge Management, Knowledge Flows, Mapping Techniques*

# 1 INTRODUCTION

Modern companies are facing a situation where the ability to develop and utilise the intellectual competences of their employees to create services of value for their customers is the key challenge (Quinn et al. 1996). This is also true for systems development companies which, in their pursuit of greater professionalism, continuously have to improve their performance. System development is dependent upon knowledge of the application domain and development practices, which is why the knowledge management field continues to attract more and more attention in the systems and software development industry (Dingsøyr 2001, Kautz and Thaysen 2001).

This study introduces the concept of *knowledge flows*, which together with an accompanying mapping technique to analyze knowledge management related issues and to improve systems development practice are described in detail.

The concept, the technique and first results have been developed in close collaboration between researchers and the employees of a systems and software development organisation in Denmark following an approach inspired by the Collaborative Practice Research (CPR) scheme (Mathiassen 2002). The CPR approach is based on a three step repeatable process. The understanding of the subject area is achieved through collection and interpretation of data about practice. On this basis propositions to support practice can be designed, and through intervention these propositions can be applied and thus improve practices. The outcome of the effort can then be used as a basis for a new understanding and triggers further improvement cycles.

The study comprises a full CPR cycle and covers 10 months of qualitative data gathering. One researcher has been present in the organisation once a week and participated in the daily routines. This enabled him to get an in depth understanding of the organisation and its culture. Eight semi-structured interviews in three interview rounds were conducted with employees from all organizational levels to further inform the researchers. Furthermore the study relies on an analysis of artefacts being used in the organisation; templates for reports, manuals describing organisational processes, computer based tools, etc.

The remainder of this paper is organised as follows: In the following section the concepts of knowledge flow and knowledge mapping, as well as critical situations uncovered by knowledge mapping are introduced. Section 3 reports from the application of knowledge mapping in practice and the paper finishes in section 4 with a brief discussion and conclusion.

# 2 KNOWLEDGE MANAGEMENT

In post-industrial organisations the primary asset is no longer the physical equipment and production environment, but instead the know-how of the employed work force. Modern products and services are based on information technology which creates new opportunities for low marginal costs, low distribution costs, and global reach (Shapiro and Varian 1999). At the same time the customers are seen to be growing in sophistication and increasing their demands (Davenport and Prusak 1998). This shift towards a ‘knowledge society’ is in itself a change of environment that every modern organisation must handle (Liebowitz and Beckman 1998) and has led to the establishing of a knowledge management discipline (Swan et al. 1999).

Knowledge management in this context is broadly understood as any process or practice of creating, acquiring, capturing, sharing and using knowledge wherever it resides to enhance learning and performance in organisations including the creation of environments in which learning and knowledge exchange can take place (Quinitas et al. 1997).

Knowledge management plays a prominent role in modern, knowledge-intensive organisations. Thus systems and software development companies have started to introduce knowledge management into their organisations, often as part of larger organisational change processes that aim at improving their software development process (Kautz and Nielsen 2004).

## 2.1 Knowledge Flows

A crucial element of knowledge management is the ability to learn, on an individual as well as on an organisational level. Learning is defined as the 'act, process, or experience of gaining knowledge or skill'[1] or, in other words, the basic task for developing and updating the intellectual capabilities and the knowledge of an organisation's employees as a prerequisite for improvement.

Learning occurs in the interplay between competence and experience (Wenger 2000), and often leads to a change in the repertoire of future behaviour (Walsh and Ungson 1991) – this interplay is, because of its cyclical nature, also referred to as the learning cycle (Hedberg 1981). Learning take place and knowledge is gained when experiences affect the cause-effect relations in memory, which again changes the repertoire of competences for future actions which – when applied – leads to new experiences etc. The learning cycle constitutes the basis for approaches to organisational learning. Wenger (2000) uses the term 'social learning' for this organisational learning cycle and describes how social learning occurs in the interplay between personal experiences and social competences.

A prerequisite for learning is that the learning cycles are complete, which implies that its various elements must somehow be connected. Experiences must be available to compare or learn from the effects of actions. Competences must be available for deciding or learning which actions might be useful in a certain context. On the organisational level this means that both experiences and competences must be exchanged and shared to permit learning to take place.

To perform proper knowledge management the organisation therefore must facilitate these exchanges. To stress the idea of these exchanges as bearers of the necessary constructs for sharing existing and creating new knowledge we call them *knowledge flows*.

According to literature knowledge flows take various shapes and forms. Following Polanyi (1966) Nonaka (1994) describes how explicit and tacit knowledge is created and transferred by and between individuals in an organisation. Although his strict distinction between explicit and tacit knowledge and the transformation process between them can be criticised, categorising knowledge in such a fashion is helpful. It points out that knowledge flows consist of both of an explicit and an implicit level, implying that an analysis of these must include externalised material as well as processes and human behaviour.

Another important element that influences knowledge management and knowledge flows, is how knowledge is 'stored' in the organisation. In their work, Walsh and Ungson (1991) describe how knowledge is 'stored' in six 'bins': In the organisation's *individuals* – that is in their belief structures, their memory stores, and in their personal records and files, in the organisational *culture* – that is in the way employees are 'taught' by the organisation to perceive, think, and feel, in the *transformations* in the organisation – that is in the actual transformation processes carried out in the organisation e.g. in standard operating procedures, in the organisational *structure* – that is in the roles and rules constituting the organisation, in the *ecology* – that is in the physical layout of the organisation, and in so called *external archives* – that is e.g. governmental regulations, former employees etc.

In a description of an organisation's knowledge and knowledge flows it is therefore necessary to represent these different 'bins'.

[1] http://dictionary.reference.com/search?r=2&q=learning (Access October 2004)

Finally, Wenger's (1998) description of communities of practice emphasises that it is the belonging to several communities of practice that constitutes people's worldview and thereby their capabilities to understand the environment they see. Wenger refers to the communities as the containers of competences, and explains how learning occurs on different levels. These competences evolve inside the communities, but are also exchanged at the boundaries between various communities. According to Wenger, the communities of practice, the boundaries between them, and the communities' members' identities play an important part in the social learning systems that constitute (amongst other things) an organisation. This suggests that any representation of knowledge and knowledge flows is incomplete without depicting communities of practices and the interactions within and between them. Thus, groupings of employees, formal and informal, and their roles, formal and informal, constitute important elements of such descriptions together with the flows of knowledge that exist within as well as between these groups.

In concrete situations we understand the concept of knowledge flows in a rather pragmatic way. It is that which those involved in analysing and improving actual (knowledge management) practice consider as a flow of knowledge.

## 2.2 Knowledge Maps

To actively support knowledge management it is important to understand what the organisation's knowledge and knowledge related constructs are, what they consist of and what their relationship is. It is therefore important to explicate and visualise the knowledge flows.

A representation of the complex organisational nexus of knowledge flows, individuals, groups, organisational procedures, (IT) systems, artefacts, reports, etc. requires a holistic approach to both the collection of input and its representation. It has to allow for generalisation based on specific issues expressed by different stakeholders, as well as for interpretation and negotiation.

A known technique for visualising and understanding complex problem situations is *rich picture* drawing where a rich picture is defined as "the expression of a problem situation compiled by an investigator, often by examining elements of structure, elements of process, and the situation climate" (Checkland 1999 p. 317). A rich picture seeks to outline a holistic presentation of a problem situation. The rich picture technique requires a thorough data collection e.g. based on interviews with representatives of all involved stakeholders. A rich picture contains different viewpoints, potential disagreements or conflicts allowing for multiple perspectives at one time. The technique allows for both insiders and outsiders to draw a complex human activity system in a picture. The technique does not favour one way of actually drawing over another, but leaves this to the picture maker(s). However, the basic elements characterising the situation have to be visualised for the picture to serve as a means of communication. Even if not all involved understand the picture the same way as the maker(s) or as it was intended otherwise, the drawing itself serves as an enabler for a discussion, which may support the development of a common understanding of the problem situation.

Various mapping techniques have also been introduced to analyse problem areas, which are not fully or consistently understood by different stakeholders. Maps are defined as being "an interpretive description of a situation" (Lanzara and Mathiassen 1985 p. 5) and are as such an interpreted model of reality i.e. a map consists of selections of relevant details of the mapped situation and provides information about what the mapmaker(s) find(s) relevant. Maps provide a possibility to gain an understanding of a complex problem situation and at the same time facilitate a common understanding of specific issues among different stakeholders. Different mapping techniques can be used to collect and organize relevant knowledge (Lanzara et al. 1985): A diagnostic map consists of a root-cause analysis in which the mapmakers discuss experienced problems and seek causes and effects to find alternative approaches to avoid the problems. *Ecological* maps outline the connections between problems and the organisational context of the problems. *Virtual* maps outline desirable future situations. *Historical* maps have a retrospective perspective as they map the past; a previous situation

is described with respect to its key events to learn what might be critical factors in a similar future situation.

An important aspect with regard to making maps is to acknowledge the mapmaking process itself as an important part of the result. The maps are the tangible results, but those involved in the creation process learn about each others viewpoints and beliefs and the process facilitates the exchange of opinions, the sharing of knowledge, and the development of a mutual understanding.

To analyse the knowledge flows in an organisation we utilise the strengths from each of the underlying techniques. The resulting map of the knowledge flows and its constituting elements we call a knowledge map[2]. The rich picture technique provides the ability to visualize the different knowledge elements in a single drawing, while the mapping techniques provide different analysis approaches for the actual drawing process and the drawing itself.

A knowledge map thus consists of the elements from a rich picture; elements of structure, elements of process, and a representation of the climate within which these two exist. The actual choice of drawing symbols is not important, it is important to choose representations, which are understandable, and direct the viewer's thoughts to the relevant elements of the experienced reality.

The structural elements of a knowledge map constitute the basic nodes of the map. They consist of the different actors and groups involved in the organisation which comprise the formal organisational constructs like the organisational units, project teams, individuals, etc. Important artefacts regarding the flows also have to be considered. This could be reports or software tools like an error reporting system. The knowledge 'storage' bins are also good candidates for structural elements in the knowledge maps.

The central process elements of the knowledge map are the knowledge flows i.e. the communication and the exchange of information etc. which flow directly and indirectly between the structural elements. These flows constitute in the terms of Huber (1991) the basis for knowledge acquisition, information distribution, information interpretation and organisational memory[3] as processes and constructs that contribute to learning in the organisation. They thus represent the backbone of the learning cycles. A flow comprises of interaction between various structural elements, and can consist of informal discussions as well as strictly formal half-year reports; what is important is that some actor acknowledges it as a means of knowledge exchange. Some flows are bi-directional, and some unidirectional, and some might be both depending on who defines them. The flows can differ with respect to their frequency and to the amount of information they contain, both important features to provide an understanding of the overall flow between various elements. It is useful to model what type of knowledge is contained in a flow. The importance ascribed to flows by different stakeholders is also a significant feature as it can bring potential misalignments into the open.

The situation climate is a key information provider. It contains expressions about the circumstances under which knowledge flows take place. This contextual information is a major indicator for pointing out problems, and contains multiple perspectives depending on the viewpoints brought forward. It can consist of thoughts about why a situation is experienced as good or bad, thoughts of how a certain situation could be improved, expressions of where conflicts arise, or other comments about the knowledge flows. The techniques for constructing diagnostic maps and ecological maps are important tools in this part of the mapmaking. By describing the climate it is possible to gain insight into

[2] The term knowledge map is widely used in different contexts - when 'googling' 'knowledge map' in October 2004 24.800 hits were returned - examples include tools to support mind mapping, category based indexing, and alternative methods of text representation; it however also fits for our purposes.

[3] A widely overlapping, but slightly different conceptualization is presented by Pentland (1995) who talks about knowledge processes which he calls construction, organisation, storage, distribution and application of knowledge which constitute (organisational) learning systems.

potential strengths or weaknesses of the knowledge transfer and sharing – important parts of the learning cycles in the organisation.

There are many different ways of applying the technique and section 3 describes the concrete way we applied it. However, it always incorporates participant involvement as a necessary condition to strengthen the relevance and validity of the map – and the therapeutic effect of discussing and cooperating in the mapmaking process is an important side effect of the technique.

During or after the mapmaking process the map can be analysed with respect to potential problems and, equally important, sections of 'well performing' knowledge flows. Incomplete learning cycles might indicate improvement areas whereas some parts of the organisation might provide good examples for other parts.

### 2.3 Critical Situations uncovered by Knowledge Maps

Both with and without the respective knowledge flows, a knowledge map helps to uncover critical situations as a starting point for future improvements.

Complete learning cycles (Hedberg 1981) based on effective knowledge management and knowledge flow are a prerequisite for learning. However, complete learning cycles might also cause problems for the organisation. Here the distinction between experience exploitation and experience exploration as two different experience management approaches (Levinthal and March 1993, March 1991) is helpful.

Experience exploitation describes a reactive approach which strives for evolving the current practices by carefully studying and analysing these and their results with the purpose of extracting information of how to adjust and (fine) tune future practices to become better at achieving the organisational goals. Thus the identification of "best" practices and the generation of means to spread these best practices among relevant organisational units are the main tasks for an exploiting organisation. The advantages of this approach are that the organisation will become expert in its field because it will continuously be able to learn from both successes and failures, but on the other hand it will be exposed to the danger of becoming skilfully incompetent i.e. so specialised that it can not react (fast enough) to changed conditions e.g. changes in the market (Argyris 1993, Holmqvist 2003) or disruptive innovations (Charitou and Markides 2003, Christensen et al. 2002).

The alternative approach, the experience exploration approach, is a proactive approach in which innovation and experimentation are used to change future practices by trying out radically new concepts or approaches. This leads to more revolutionary changes, which can be used to achieve competitive advantages. This approach can prevent an organisation from becoming skilfully incompetent, but is itself no silver bullet as its explorative nature makes returns "less certain, more remote in time, and organizationally more distant from the locus of action and adaption." (March 1991 p. 73).

Levitt and March (1988) describe how this also has an influence on situations where organisations rely heavily on 'learning by doing' and describes how diffusion or 'learning from the experiences of others' is an important aspect of not falling into a competency trap. Closely related to these distinctions are also the concepts of single loop learning and double loop learning with single loop learning referring to the situation, where error detection and correction, response and action, do not change the underlying norms and fundamental competences, whereas double loop learning describes the situation where responses lead the organisation to search for error corrections deeper in the theories-in-use in the organisation (Argyris and Schön 1974).

Hedberg (1981) further stresses how an important part of this changing of behaviour is to unlearn 'wrong' stimuli-response connections and he emphasises the importance of not clinging to irrelevant or wrong knowledge. Similarly, communities of practice can steward a critical competence, but they can also become hostage to their history, insular, defensive, closed in, and oriented to their own focus (Wenger 2000). Thus, the analysis of the map should be informed by the organisation's intentions with

respect to whether an exploitation or exploration approach is seen as beneficial in a specific area. Similar organisational units might achieve advantages from having a close dialogue and sharing of their experiences, if no knowledge flow exists between them, a potential benefit might be lost.

Incomplete learning cycles, however, may seriously jeopardise learning. Hedberg (1981) describes how learning cycles can be incomplete and distinguishes four situations in this context: (1) role-constrained learning where the link between individuals' beliefs and their actions is not aligned because of constraining formal roles or rules; (2) audience learning where individual action does not directly affect the organisational action as the individuals do not have enough capacities to change the organisation in a desired direction; (3) superstitious learning where due to a misalignment between the organisational action and the environmental responses, responses wrongly are assumed as resulting from organisational actions; (4) learning under ambiguity where the environmental responses can be the cause of different interpretations amongst the individuals in the organisation. On this basis we have identified four critical situations, which might point to potential problems and improvement possibilities:

(1) *Missing links* describe situations where a link would be beneficial, but for some reason is not there or not functioning satisfactory. As such, missing links are problematic to spot in a map, but to look for incomplete learning circles is an obvious starting point.

(2) Areas from where lots of flows origin, but none are going in are *springs*. These might indicate potential innovative centres where lots of ideas are created and exported to the rest of the organisation. A spring might also point to an area, which is not using others' experiences. This is not necessarily a problematic situation, as it can represent a highly specialised unit, which does not need any input, but it might as well point to a potential problem in that superstitious learning might be the outcome.

(3) *Black holes* are places where no flows origin. This means that knowledge only flows one way towards this area. This might not be problematic, but if learning from experience is an important part of the organisational development, and specific parts of the organisation are not feeding experiences back, it is not possible for other parts to learn from these.

(4) A specific individual or organisational unit with a large number of connecting knowledge flows, we call a *hub*. A hub might be useful to have in an organisation, if it can cope with the knowledge flowing to and from it, and can effectively use it, but too many flows ending in one place might easily create congestion and thus a hub might end up in developing into a bottle neck slowing or discharging knowledge flows. This can lead to a situation, where employees believe their actions affect the environmental response, but in reality they do not, because of a slow or dysfunctional knowledge flow.

# 3 KNOWLEDGE MAPPING IN PRACTICE

The case organisation is approximately 20 years old and develops complex IT solutions within information and communications systems. It employs about 300 people, mostly system engineers with an academic background. All development is organised in projects and the project teams are quite stable: most developers only work in one project at a time. The projects are large, 55% of them larger than 10.000 working hours. Continuously 20-25 customer projects exist simultaneously and the typical project develops new applications for one customer, but some of the applications are off-the-shelf products with long lasting projects for maintenance and further development.

The company is highly involved in developing its abilities to produce software, and 8 years ago adopted the capability maturity model (CMM) (Humphrey 1989) as a basis for conducting software process improvement (SPI) efforts (Aaen et al. 2002). At the time of the intervention the company was at CMM level 3, but it later reached level 4. The organisation has followed knowledge management principles for a number of years and has a fairly developed knowledge management system (Arent et al. 2002). The efforts are rooted in a SPI team, which employs about 15 full time staff.

The application of the knowledge mapping technique commenced from a situation where members of the SPI team had experienced occasions where knowledge about development practices and improvement proposals did not flow as desired between development projects and the SPI team.

Following the layout of a CPR cycle first a thorough data collection where conducted to examine if and to which extend these issues where shared with other parts of the organisation, and if so, how others understood and explained them. Then, based on this broad conception of the situation, the researchers developed the knowledge mapping technique, which finally were applied as a means to identify areas of improvement. In the following the critical part of this process, the knowledge mapping itself, is subject to a detailed description.

### 3.1 Creating and Analysing the Knowledge Map

The actual approach to applying the knowledge mapping technique consisted of two phases, a preparation phase conducted by a mapmaker, and a collective mapping phase in which two leading members of the SPI team together with four researchers created the actual map.

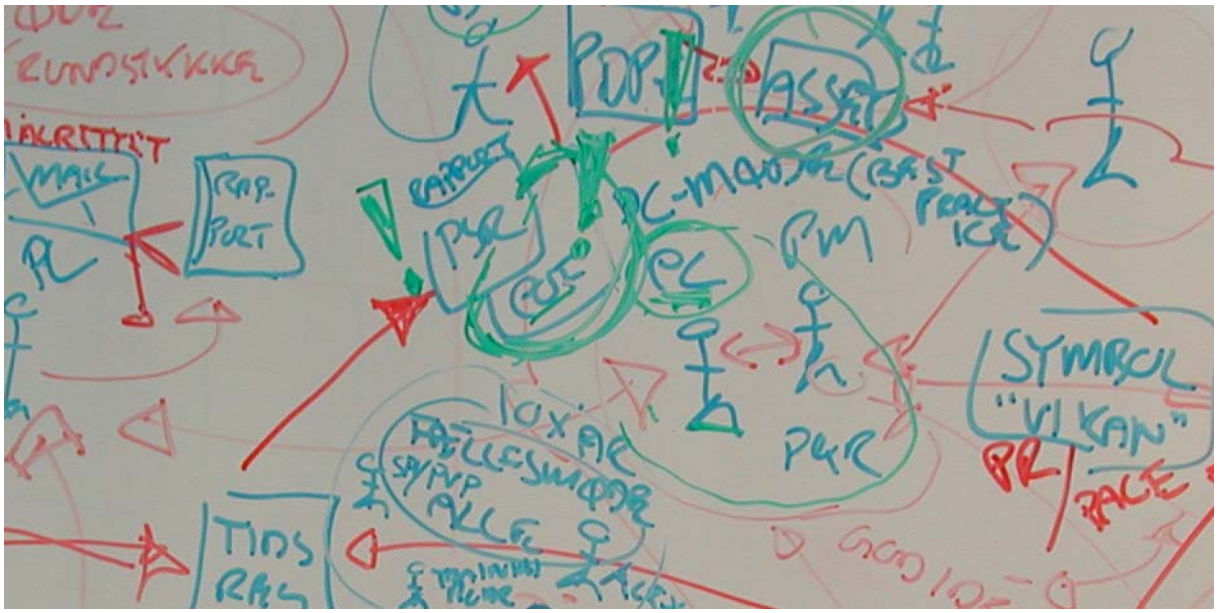


*Figure 1. Excerpt from the final knowledge map*

The first phase was carried out by one of the researchers, who had also conducted the data collection. He made a preliminary knowledge map of the organisation as a preparation for the definite joint map creation session based on the data he had gathered over a period of 10 months. This map could be followed during the joint map creation phase, and kept the task on track, even when discussions moved in different directions. Preparing the map in advance ensured that, for the original mapmaker, relevant aspects were covered. It allowed the mapmaker to prepare a note of questions on topics, which he felt were not explained satisfactory in the collected data. Drawing the map in advance also provided the opportunity to list what he saw as major problems and improvement areas. These were used as discussion topics, in situations where the process needed stimulation. Preparation of a map in advance, without interference from others, enabled him to record his understanding, and thus provided the whole joint mapping phase with the quality of having an outsider look at the organisation. This external input would not have been so clear if organisational representatives would have had the opportunity to influence his views in advance.

The second phase was the actual mapping phase, the joint creation of the map. It consisted of four steps and took place in a day long meeting session. The steps together functioned as verification,

clarification, and extension of the mapmaker's preliminary map. The various elements of the map were discussed in an open atmosphere. The mapmaker was acting as the meeting leader and he introduced and facilitated the process. Because not all stakeholder groups were represented, the mapmaker with the outset in his own map brought the viewpoints of these groups forward in a stepwise manner. He was also responsible for leading the discussion, and for documenting the results on a white board.

The first step consisted of drawing all important elements of structure on a white board. The mapmaker selected one area of the organisation to begin with and started drawing organisational units, artefacts, people etc. listed on the preliminary map. While doing this, he presented his understanding of the role of each of these. This promptly initiated a discussion among the participants, because some of the descriptions were not correct according to their opinions. To represent individuals we used 'stick figures', some with additional characteristics because they represented individuals with specific roles and importance. We used groups of stick figures to represent certain organisational units, like development projects and sometimes we encircled these to mark specific boundaries with the context. We used a picture of a document to represent written reports, and their formal abbreviations to distinguish them. Furthermore we used various symbols for technical systems; these symbols were easy to understand for all participants, and were if necessary, equipped with explaining text.

The second step consisted of describing all different knowledge flows. The meeting leader introduced a specific flow between two or more people or artefacts, and described his understanding of it. This quickly facilitated a discussion outlining special cases and corrections, providing clarification and richness to the map. This step also introduced overlooked people, roles, and artefacts to the map.

The third step concentrated on the climate providing the context for the knowledge flows. For this purpose characteristic statements identified during the data analysis were added to the map. The step included a discussion of which flows were found problematic, and which flows were missing. When we conducted this step a lot of new problematic issues surfaced, and the organisation's representatives became defensive. The meeting leader steered the discussion away from this position, and emphasised the opportunity to develop ideas for improvements. The focus was directed towards addressing the question of why some members of the organisation experienced these problems, even if the SPI team's representatives did not acknowledge them. Here, the mapping technique showed its value, since it was possible to demonstrate that some might experience problems or conflicts, where others were not seeing them. A new colour was used to highlight the problematic areas, and they were denoted with a large exclamation mark. Finally, this step was also used to indicate on the map where new ideas and initiatives originated by marking these with a light bulb.

The fourth step consisted of analysing the identified problems in order to understand their roots and causes. This discussion supplemented the map with a list of identified improvement areas. The map allowed the diagnosis of each problem with its particular context with respect to structure and process, which made it easier to identify what parts of the organisation were affected, and should maybe involved in the search for a solution.

Even though the steps above are described as a linear process, the actual mapping was characterised by letting the discussion follow interesting topics, and thereby mapping larger organisational 'chunks' rather than finalising each step at a time. Thoughts were allowed to drift, and the discussion moved more iteratively from one topic to another and the meeting leader had his own map to fall back on when the process needed to proceed. To allow for further analysis and as the documentation of the map creation process, the last item of the agenda consisted of photographing the map on the white board.

### 3.2 Outcome of the Analysis

A primary result of the analysis pointed out that knowledge and key information regarding development projects was collected in formal project reports. The project managers responsible for

creating the reports felt that these reports never reached the SPI team. As a consequence the project managers spent less time providing this knowledge and information, thus making fewer experiences available. On the other hand the SPI team felt that the reports offered very little of relevance, and therefore did not spent much time analysing them. The recognition of this incomplete learning cycle led to the development and implementation of a new project evaluation concept, which integrates the project reports and the diffusion of experiences through the company's formal knowledge networks. Applying Hansen et al.'s (1999) work and utilising the best of each approach it combines codification and personalisation strategies to a promising knowledge management scheme.

The situation described above can also be understood as a missing link: Beyond the problems with the written reports, many projects felt it difficult to feed their experiences back to the SPI team, which as a consequence, had fewer experiences to base their work upon. The analysis also identified a spring: Top management continuously feeds the organisation with new ideas and suggests new initiatives; this can become problem, especially in situations where the organisation first needs to settle with and evaluate an ongoing initiative before starting a new one. Also black holes were discovered. A serious one was one of the organisation's knowledge sharing tools. It was mainly used by the employees to store experiences, but hardly applied to search for help. This made it a 'write only' asset from which little or no knowledge was fed back to the organisation. Lastly, a hub came also into sight. One prominent person had several roles in different parts of the organisation, the map showed that many flows led to him and many came from him. Again, while this does not have to be an immediate problem, it can cause severe difficulties, if this person falls ill or chooses to leave the organisation. The detection of these critical situations now provides the possibility for future improvement actions.

A final result of our analysis which confirms the map's function as a device to support understanding and consensus, was the broader comprehension of the knowledge flows by and among the participants of the session. When the participants were presented with viewpoints other than their own, they had to reflect upon these, and this had an impact upon how they saw the situation, and provided them with a better basis for an analysis in the future.

# 4 DISCUSSION AND CONCLUSION

Based on the insight that understanding the knowledge flows in an organisation will support systems development practices we describe in this paper how in a close collaboration with the employees of a systems and software development company we identified possibilities for improvements. For this purpose, we introduced the concept of knowledge flows and developed and applied a knowledge mapping technique visualising the relevant organisational units, individuals and artefacts, the knowledge flows between them, and the climate and context in which these flows take place. In this context the concepts of springs, hubs, black holes, and missing links have been helpful to structure the (discussion of) knowledge flows. We used a range of qualitative data gathering methods throughout a 10 months period to inform the application of the mapping technique in the organisation. We conclude that this mapping technique provided a helpful means to understand the complexity of the knowledge flows in a systems and software development company with many simultaneous projects. The technique produced valuable results when it was applied in the software company as it provided understanding and information about where and which improvements could be relevant.

In the described setting the knowledge mapping technique provided the organisation with useful results and valuable feedback, but the same setting might not lead to the same achievements in another organisation or with other participants. The technique as such is no silver bullet and no guarantee for success. In the case study long-term cooperation and the extensive presence of the researchers in the company, mutual respect, trust and a sincere atmosphere had developed and allowed for a frank dialogue and discussion through data collection and in particular throughout the final mapping session. The researchers and especially the producer of the original map were acquainted with the

organisation's culture and overall values, its language and concepts as well as their procedures and tools. This facilitated the mapping process, which was focused and progressed easily without significant problems. But the close relationship with company and the employees presents also a danger. The apparent inside knowledge might lead to misconceptions and a distorted image of the organisation. Here, though, the collective mapping session, in which matters are openly discussed by representatives of different stakeholder groups, functions as remedial action.

However, our approach, which relies on and addresses all relevant personnel to get a view of the practice as perceived by all stakeholders, might be criticized as only SPI management and no ordinary project members were present at the mapping session. One might argue that involving more personnel in the mapping session and providing more resources for the process could avoid this. In our case resources were limited and the research team decided that for a pilot test of the technique a smaller forum would be adequate. The conflicting demands were balanced and compensated by using a mapmaker, who was well acquainted with and trusted in the organisation. This way an outcome was achieved, which were not restricted by management views and limited input. The quality of the analysis was confirmed by the fact that the resulting improvement proposals were positively received and accepted by other members of the organisation than those who participated in the mapping session. In this context, the use of rich pictures also has to be considered carefully. Checkland (1999) underlines that some people can easily handle rich pictures whereas others have problems with drawing and discussing them. In our case the researchers all had experience with rich pictures and could thus help the other participants with the use of the technique. It was also beneficial to support the use of rich pictures with a meeting leader, letting him draw the first version of the picture.

Our technique, the case description and its analysis, contribute to the existing body of knowledge in the field of systems development, with an alternative approach to gaining the necessary understanding of the development settings to be able to identify potential knowledge-related improvement areas. The technique does not rely on any specific software development model, but is instead problem-driven. This makes the improvement areas grounded in the actual settings and thus relevant to the organisation, but at the same time, the technique does not prescribe or promote any specific improvement ideas. By introducing a knowledge-oriented view upon the software development field, and by raising knowledge- or learning related issues in software developing organisations our work can act as a link between on one side the software development field and on the other the knowledge management and organisational learning fields and this way provide a broader sphere of possible improvements in software companies.

The technique was developed and applied in a systems and software development company, but this company is only an exemplar of a contemporary, knowledge-intensive organisation, thus constituting an ideal setting for testing the approach. We believe that the technique is also applicable and will provide useful outcomes in other knowledge-intensive organisations in different commercial or public settings. To refine the technique, this as well as other concrete instantiations of the approach, must be subjected to future research.

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