Knowledge Mapping: A technique for identifying knowledge flows in organisations

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***Abstract**: For modern organisations – including software developing companies - knowledge is a key parameter for surviving, because the ability to continuously become better at producing services relies on the abilities to incorporate the earlier experiences into the planning of future practice. These abilities depends highly on the organisation's ability to share knowledge and thus on the way knowledge flows in the organisation. In this paper we present a knowledge management perspective on the software process improvement (SPI) field, and describe how we use rich pictures as a technique for mapping the organisational knowledge flows in a Danish software company. The results show that the technique successfully helps the organisation select relevant focus areas for planning future improvement initiatives. The study further uses the map to explain four distinct critical situations, which can be identified in a knowledge map; Hubs, Black Holes, Springs, and Missing Links. Each of these situations covers potential problems in the organisational flows – and therefore can provide guidance towards organisational improvements.*

***Keywords**: Knowledge Maps, Software Process Improvement, Mapping Techniques, Rich Pictures, Knowledge Management*

1. Introduction

This paper is based on a study conducted in a Danish software organisation, which has adopted the Capability Maturity Model (CMM) as a basis for improving their development capabilities. In their strive for achieving the highest levels of the CMM, the team responsible for organising the improvements has experienced situations where knowledge has stranded or is lost in parts of the organisation.

To find out whether this is the case, and where the potential problems occurs we in this paper present a knowledge management perspective on the Software Process Improvement (SPI) field by providing a means for analysing the knowledge flows in an organisation to allow for a better understanding of the organisations ability to share knowledge. We do this by developing a technique for mapping the communications streams among the organisational actors, and show how this technique is applied within the organisation, with the purpose of providing useful input to the organisational unit responsible for the SPI activities in the organisation, and thus enabling them to select relevant focus areas for future improvements.

The paper is constructed as follows: In the following section the theoretical background for the mapping technique is explained. Section 3 describes the research method, and section 4 provides a short description of the context in which the study is conducted. Section 5 gives a detailed description of the knowledge mapping technique. Section 6 describes the results of applying the knowledge mapping technique into an organisation, and these results are discussed in section 7. Finally the paper is concluded in section 8.

2. Background

Knowledge is a key concern in modern organisations because it is a company's ability to make use of its experiences that constitutes the core assets in organisations which sells know-how or services – like software. The actual production environment and infrastructure (i.e. technical development environments, tools and platforms) plays a diminishing part in these companies and the knowledge available in employees and teams – and the management of this knowledge - a growing role .

The use of previous experiences to leverage a company's knowledge has been a primary concern for organisational research for the last decade and Knowledge Management an important discipline . One key element in the knowledge management is to evolve the practices by carefully studying and analysing the current practises 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 creation of means to spread these among relevant organisational units are a primary task in knowledge management.

Software companies are service producing companies and thus the main asset in these companies is knowledge, which means that the ability to manage this knowledge and use their experiences is one of the major tasks in this type of organisations. Addressing these issues the Software Process Improvement (SPI) field has grown out of the software engineering discipline inspired largely from the manufacturing industries rational approaches to planning and designing improvement strategies like TQM e.g. (Zultner 1993). The first initiatives using the SPI title were originating from Watts Humphrey at the Software Engineering Institute (SEI) in the late eighties , one of which are the currently best known of all SPI approaches the Capability Maturity Model (CMM). CMM is derived from studying a large number of US software companies and extracting a set of norms, which constitutes a sound portfolio of practices. The model consists of a description of five levels of maturity a software company should go through to improve their software developing capabilities. The higher (or mature) levels of the model stress the ability to build future practices (or processes) on previous experiences – adjusting and fine tuning them accordingly to successes and failure .

A prerequisite for strengthening the knowledge management is a good understanding of how the knowledge flows in the organisation. These flows are important in two ways as they provide insight to where new ideas or initiatives originates and how knowledge about these spread to the rest of the organisation.

The ability to pinpoint the places and organisational units where new ideas and initiatives arise from is an important factor when wanting to manage a more proactive improvement approach, because the organisations employees often are able to help finding radical new practices, and also because the involvement of the employees can act as a positive encouragement to employees to participate in the innovative process thereby strengthen their motivation for later adapting new practices . When knowing where the creative centres in the organisation are located it is easier for management or change agents to facilitate and nurse the new initiatives and let them evolve to be useful for the whole organisation.

An understanding of the knowledge flows can help both in a proactive way to spread new ideas and insights via the established (not necessary formal) channels, but also in a more reactive way by making it possible to predict what effects a specific change might lead to in the rest of the organisation. Another important aspect is the ability to identify where knowledge does not flow as intended - bottle necks – which can be a hindrance both for diffusion of new ideas but also for the feed back on effects of innovations.

Several studies have shown that the actual practice often differs from what is

described in formal plans and guides. This implicates that it is necessary to conduct an actual examination of the organisation to understand practise, it is not enough to rely on formal descriptions and organisational charts and plans.

In this context this means that it is necessary for organisations to develop a picture of how knowledge flows among different actors in the organisation, which is why we in this paper develop and test a technique for mapping the these flows in an organisation.

3. Research Method

This paper reports on the first part of a study of a software company in Denmark. The overall study is based on a close collaboration between the organisation and the researchers allowing both to mutually benefit from the results.

This close working together has previously been described by Mathiassen as the "Collaborative Practice Research" approach .

The approach is based on a three step repeatable process with different research activities addressing different knowledge types. The *understanding* of the subject area is achieved through collection and *interpretation* of data about practice. Based on this understanding normative propositions to *support* practice can be *designed*, and through *intervention* these propositions can *improve* practices. The outcome of the improvement effort can then be used as a basis for a new *understanding* and so forth...

In this study a number of different data gathering techniques are used to analyse and diagnose the situation in the company, which lead to the planning and design of an actual intervention.

The part of the study we report in this paper covers 10 months of work and the collaboration is arranged around a formal steering committee in which two representatives from the organisation and six researchers participate. The steering committee, which meets approximately bimonthly, functions as a planning forum, where new initiatives are planned and the results hereof are discussed. The results from analysing the data gathered are presented and discussed on the steering committee meeting as well.

3.1.1 Presence/Observation

One researcher is being present in organisation once a week – participating in "what-ever-happens-now". This presence has provided the research with a detailed insight into many "taken-for-granted" situations, which often will not be explicated during formal interviews or conversations. The researcher this way has also participated (both with active and observing roles) in a number of meetings and employee courses.

The ability of the researcher to ask "W*hat happened just there?*" in or just after the occurrence of an activity/happening of interest, makes it possible to explore and describe non-formal communications and practices, and provides the researcher with a broader view of the organisation allowing for a more detailed understanding of the organisation – and thus a more precise ability to conduct a valid analysis.

The information gathered from the many visits is documented in a diary, which the researcher keeps. Besides this a dictionary (or small encyclopaedia) explaining and documenting the many different organisational constructs and concepts supplements this diary as a means of informing the later analysis.

3.1.2 Interviews

The researchers have conducted eight semi structured qualitative interviews in three interview rounds with representatives from different levels of the organisation, and with different roles.

These interviews are based on an interview guide and are used to inform the researcher about how the respondents interact with other members of the organisation, and with other organisational units. The interviews also focus on exposing how the different employees coordinate and organise a typical working day, and what tools and other means of communication are used.

The interviews are tape recorded and an expansive resume afterwards written allowing for later consulting and analysis.

3.1.3 Artefact analysis

The study also included an analysis of artefacts used in the organisation in the software development processes.

Artefacts in this relation covers templates for reports, manuals describing organisational processes, computer based tools used in the development projects.

4. Intervention Context

To explain the context and the specific situation of the study a short description of the company is included in this section. The description also includes a short explanation of the situation in which the intervention is conducted.

The company in which the research takes place is a Danish Software company employing more than 300 people, which make it a larger software company by Danish standards. The employees consist mostly of system engineers with an academic background.

All development is organised as projects, and the project teams are quite stable meaning that most developers only work on one project at a time. The projects

are large with 55% of the projects larger than 10.000 working hours. Continuously some 20-25 customer projects (not-internal projects) exist simultaneously in the company. The typical project develops new software applications directly to one customer, but some of the applications are more like off-the-shelves products with long lasting projects for maintenance and further development.

The company is highly involved in developing their abilities to produce software, and has adopted the CMM as their basis for conducting their SPI efforts. At the time of writing the company has achieved a CMM level 4 compliance.

The SPI efforts in the company are rooted in a SPI-team, in which employs approximately 15 full time employees. The improvement effort is mainly based upon the development and implementation of a Business Manual (BM), which is an Intranet based manual describing how project management, software development, etc. should to be carried out. The SPI-team also participates in the educating of project managers and other project members in how to implement the requirements from the BM. The individual projects must comply with the BM, and are audited from time to time by an internal auditor.

The company's representatives in the research projects steering committee are the manager of the SPI-team, and the manager for the business area in which the SPI-team is located.

4.1 Intervention context

The study takes its outset in a situation where members of the SPI-team have experienced that communication in the organisation is somewhat troubled. An example could be that relevant information about a project's achievements and results never are fed back to the SPI-team making it difficult to evaluate if the project could provide the SPI-team (and thus the organisation) with some valuable experiences. Also examples of the general sharing of ideas and good or bad practices are seen to be affected from a lack of abilities to share knowledge among the organisation's members. This has led the SPI team worrying that knowledge sometimes is lost in the organisation.

Several explanations of where this lack of communication origins exist e.g. the employee does not know where to go with the information, the receiver of the information can be overloaded with information, and thus not have the resources to deal with the extra amount of information, the different parts of the organisation can be so different that it can be difficult to understand the problem and solution etc. But mostly these explanations are based on assumptions and general ideas of organisational problems, and the complex context of the daily life in the organisation makes it difficult to conduct a valid study within the resource budget.

No matter the cause, the problem is feared to affect the organisation's

possibilities to extract and spread useful information among its members, and this again is feared to lead to a negative cycle where employees have no incentive to share knowledge because they experience that an extra effort in this direction is wasted anyway.

In this context the SPI team and the researchers want to conduct a more thorough study to find out whether the problems exist, and if so where and to what extend.

5. Knowledge Maps

In this section an overview of existing techniques for addressing complex problem situations are presented, which leads to the introduction of knowledge maps as a technique for analysing the knowledge flows in an organisation.

5.1 Rich Pictures

A technique for understanding complex problem situations is *Rich Picture* drawing . Checkland defines rich pictures as "The expression of a problem situation compiled by an investigator, often by examining elements of structure, elements of process, and the situation climate." These pictures seek to outline a complete holistic drawing of the problem area instead of focusing on specific problem situations.

The building blocks of a rich picture consist – besides the structural and process elements of the situation climate, which should be rendered as expressed by the participants in the system. In this way the rich picture technique require a thorough data collection e.g. based on interviews with (representatives of) all different actors in the system. A rich picture thereby will contain different viewpoints and potential disagreements or conflicts allowing for multiple viewpoints and perspectives at one time.

Originally the technique is intended to be used in the Soft Systems Methodology to help information systems builders to comprehend, understand and verify complex work situations and tasks as part of the analysis of the Human Activity System.

The technique does not favour one way to actually do the drawing over another, but leaves this to the creator – but the basic elements (structure, process, and climate) should in some way be represented and visualised. The visualisation is a very important feature as it is through this the picture can be used as a means of communication. Via the rich picture technique it is possible for an outsider to draw a complex system in a holistic picture which is well suited for communication. People can easily comment on a picture – maybe they do not understand it the same way as the maker – or as it was intended – but it suits as a conversation enabler or discussion starter, which can lead to a common

understanding of the problem situation. Rich pictures also allows for an explorative approach to understanding the problem area, because of its communicative nature.

5.2 Mapping Techniques

Also various *Mapping* techniques have previously been used in situations where the problem area is not fully understood and maybe at the same time understood differently among various onlookers and participants . Maps are by these authors defined as being "an interpretive description of a situation" and in that way a map is a model of the reality, but an interpreted model i.e. a map consists of selections of relevant details of the mapped situation. In that way a map provides information about what its creators find important and relevant. The strengths with mapping techniques are, that they both provide a possibility to gain an understanding of the complex problem situation, and at the same time it facilitates a common understanding among the participants .

The same authors describe how different mapping techniques can be used in systems development projects to collect and organized relevant knowledge, which easily would have been neglected, and develop four different types of maps, each of which have different characteristics to address different problems. These are *Diagnostic*, *Ecological*, *Virtual*, and *Historical* maps .

A *diagnostic* map consists of a presentation of the results of a root-cause analysis in which the participants discuss experienced problems and together seek the cause and the effects of these problems, and also try to find sound alternative approaches to avoid similar problems later.

Ecological maps outline the connections between the problems experienced and the internal and external conditions in the organisation, and in this way help pointing out the organisational context of the problem. The mapping technique seeks to define which conditions influence the problem situation and whether these conditions are to be found within the project team or outside.

Virtual maps outline desirable future situations, and takes their outset in asking "What do we want?" and "How do we get there?". Further different alternatives and their outcomes are considered, and the result is a description of different roads to achieving the desired outcomes.

The *Historical* maps on the other hand have a retrospective perspective in the way that they map the past. In these map a previous project is described with respect to its key events, and relates these with the actions and conditions (so-called "events-actions-conditions" loops). The historical maps can be used to learn what might be critical factors in a future similar project.

In the context of our study Diagnostic and Virtual maps are especially interesting, as they are used to understand the current situation of the project (or organisation) – and thereby provide an overview of the current status of the

mapped situation enabling a closer examination of the parts, which is seen as interesting.

The mapping technique incorporates participant involvement as a necessary condition for the technique to have any relevance or validity. This stresses that the mapping technique, besides finding alternative approaches, also has a therapeutic effect, in that the participants have to agree upon which problems are actual problems – and how they affect the different participants in their different project roles. So knowledge transfer and mutual understanding are elements in the technique, which makes it an integrated part of the actual problem solving method, or formulated differently; the maps are not as important as the mapping itself! . This means that the maps are not intended to be a means of communication among others than the actual participants.

5.3 A Knowledge Map

The maps themselves can also serve as a means of communication between different participants and therefore the actual maps is somewhat important too, which is why we in this paper introduces the use of *rich pictures* as a *mapping* technique for analysing the knowledge flows in an organisation. This we way utilise the strengths from both; the mapping techniques ability to gain a common understanding and the rich pictures to provide a holistic, understandable, and visual means of communication.

We do this by introducing the concept of *knowledge maps*, which we define as being a rich picture representing the knowledge flows in an organisation.

A knowledge map consists – as a rich picture – of the elements of structure, elements of process, and a representation of the climate within these two exists, each of which will be described below.

5.3.1 Elements of structure -> People and Artefacts

The basic elements of a knowledge map are the different actors involved in the mapped situation. This is the formal organisational constructs like the organisational units, project teams, individuals etc.

But since much modern communication is not done directly between human beings also important artefacts regarding the flows of interaction within the systems should be considered. This could be tools like an error reporting system or documents like a report created by some to be read by others.

These elements constitute the basic nodes of the map between which knowledge flows.

An important task is to define a suitable level of granularity. Instead of listing 25 different, named projects it can be useful to use some sort of generalised project – e.g. a common notion which represents groups of projects which does not have any differences in relevant characteristics. This will keep the number of

elements in the map lower, which again will make it easier to comprehend and analyse later.

The same applies to individuals – in many organisations some individuals have many different tasks, and thus represents different roles in different situations. The same individual can also be a member of different organisational units. On the other hand many individuals are "just" members of a project or a certain job description, and can be represented in the map via this role.

On the other hand it is important to be very open to include all relevant structures, because missing some might make it more difficult to identify the relevant flows (described below) – after all it is a *rich* picture.

As mentioned above the actual choice of drawings are not important, instead it is important to choose representations which are understandable, and thus direct the viewer's thoughts to the correct elements of the reality. A map is not useful if one does not know the meaning of the signs.

5.3.2 Elements of process -> Knowledge Flows

Between the structural elements the knowledge flows appears. These are lines representing the knowledge flows in the organisation.

A flow consists of some sort of interaction between various structures in the systems mapped, and can therefore consist of informal discussions around the water cooler as well as strictly formal half year reports, what is important is that it is acknowledged by some actor in the systems as means of communication. Some flows are bidirectional, and some unidirectional, and some might be both depending on who defines them!

The flows can also 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 can be useful to try to model what type of information is contained in the flow, to better understand the communication situation.

The importance the participants ascribe to the flows is also an important feature to register – especially if they vary between the sender and the receiver, in this case a potential misalignment might show up, when climate or context of the interaction is described which is the topic of the last element of the knowledge map.

5.3.3 Climate -> Context

The climate or context of the various situations in the mapped system is a key information provider when comes to the actual analysing of the map. This element contains the various expressions about under which circumstances the interaction takes place. This contextual information is a major indicator for pointing out problems in the flows, and this additional dimension in the map is what makes it truly rich.

Information of this kind can consist of the actor's thoughts about why a situation is experienced as good or bad, and thoughts of how this situation could be improved, it can be the actor's expressions of where conflicts (continuously) arises, or it can be other meaningful comments about the knowledge flows in the organisation.

These attributes of the map is most certainly not viewed upon the same way among the various actors through out the organisation, and thus it is in these an important key to finding improvement areas lays. These differences is not necessarily problematic, and different tensions will always exist in a complex social system, therefore the focus should be on listening an understanding, instead on discussing why a viewpoint is right or wrong.

5.4 Knowledge Mapping

A knowledge map is the result of a process, which – as described above – in itself is a major part of the aggregate result. Below we describe how the knowledge map was actually created in our case as a combined effort between members of the organisation and the researchers.

The technique consists of two major phases, a preparation phase, and the actual mapping phase.

5.4.1 Preparation phase

The preparation phase was conducted by one of the researchers who also had been conducting the data gathering as described earlier.

Based upon a thorough analysis of the interviews, the diary, and informed by the dictionary, the researcher created a preliminary knowledge map of the organisation.

The major reason to conduct this initial mapping was to let the researcher prepare himself very carefully before the actual mapping took place – this helped him to have an agenda (a final map) to follow during the session which acted as a connecting thread through out the session keeping it on the right track, even when the discussions moved of in different directions. The map prepared in advance secured that all important aspects were covered. It also let the researcher note a set of questions on the topics, which he felt were not explained satisfactory to be understood.

Drawing the map in advance also provided the researcher with the opportunity to have thought of and listed what he saw at the major problems, and the major improvement areas in the organisation. These were used as discussion topics, in situations where the process needed stimulation to proceed.

5.4.2 Mapping phase

The process is a very important part of this technique, and involving the actors

in the process is a crucial element of the whole outcome. Of course the map shows some important features of the organisation and the analysis of the various flows and grouping of flows provide the input needed for further action, but the map cannot be made without close cooperation of the actors from the system. It needs to be verified by actors, and will otherwise most likely not be correct i.e. not addressing all important aspects.

This is why the actual mapping phase was conducted in close collaboration with representatives from the organisation. The knowledge mapping technique as we present it here consists of four steps, and was conducted in the steering committee in a day long meeting. The four steps together form a creation of a knowledge map which functions as verification, clarification, and extension of the researcher's pre-analysis and it is through this process that the actual *mapping* activities takes place – that is, it was during this process, that the problems were discussed and thus consensus created.

The researcher, who conducted the preparation phase, was acting as the meeting leader – and it was his job to describe and facilitate the process. The meeting leader was responsible for leading the discussion, and for documenting the results on a white board. It was also the responsibility of the meeting leader, that everybody participated, and that all the relevant aspects of the system were covered, which is why he had prepared a preliminary map in advance.

The 1st step consisted of drawing all the important elements of structure on the white board. This step took its outset in the meeting leader selecting one area of the organisation to begin with and started drawing organisational units, artefacts, people etc. listed. While doing this, the meeting leader presented his understanding of the role of each of these. This promptly initiated a clarificative discussion among the participants, because some of the descriptions were not quite correct accordingly to their definitions. This is why it can be a good idea to start with the roles and units in which the members present belong, because the participants almost always will have something to add or correct to their own roles in the system, and this facilitates their involvement into the discussion.

To represent individuals we were using "stick figures" – some with additional characteristics because they represented specific individuals with specific roles and importance to the system. We were using groups of stick figures to represent certain organisational units, like development projects – and sometimes we were encircling these to mark specific boundaries with the context. We were using a picture of a document to represent written reports, and used their formal abbreviations to separate them. Furthermore we were using different symbols for a technical system to collect data about the projects (a hard drive symbol) and for an error reporting system (a computer monitor) – these symbols were easy to understand for all participants, and the more generic symbols were equipped with explaining text.

The 2nd step consisted of describing all the different communications flows. To do this the meeting leader introduced a specific flow between two or more

people or artefacts, and described his understanding of it. This did also quickly facilitate a discussion outlining special cases and other corrections, providing clarification and richness to the map. This step did also – as expected – introduce overseen people/roles/artefacts/etc. to map, making it even richer.

In the 3rd step the context to map was added by providing it with the expressions collected during the data analysis. It included a discussion of which flows were found problematic, and which flows were missing. An example was that everyone agreed that the flows flowing back to the SPI-team were not serving their purpose satisfactory. The organisation's representatives did go into a kind of defensive position, because it was during this step, that a lot of new problematic issues surfaced. It was very important that the meeting leader directed the dialogue away from this defensive position, because this seldom will be very enriching. Instead the focus was directed towards addressing the question of why some members of the organisation were experiencing these problems – even if the SPI-team's representatives did not themselves acknowledge them as real problems. This way the mapping technique actually showed its worth, since it was possible to show, that some might experience problems or conflicts, where nobody else is seeing them. We used a new colour to highlight the problematic areas, and were identifying them with a large exclamation mark. We also used this step to mark out on the map where new ideas and initiatives were originating marking these with a light bulb.

The 4th and last step consisted of diagnosing the identified problems to understand their roots and causes. This discussion supplemented the map with a list of improvement areas identified. The map provided the diagnosing of each problem with this particular problem's context with respect to structure and process, which made it easier to identify what parts of the organisation were affected, and maybe should be involved in the search for a solution. A primary result from the analysis in the organisation pointed out, that a key source of information regarding the development projects where collected in formal project reports. The project managers responsible for creating these reports felt, that these reports never reached the SPI-team, who was supposed to analyse them, and utilise the lessons learned from them into organisational practice. Because of this the project managers spent less time extracting this information, providing fewer experiences to the SPI-team. On the other hand the SPI-team felt that the reports provided very little relevant information, and therefore did not spent much time analysing them.

This simple example on a negative cycle which – if not taken care of – eventually will destroy a knowledge flow in the organisation, shows the general idea and potential benefits from the mapping technique.

Even though the steps above are described as a neat linear process the actual mapping was characterised by letting the discussion follow certain interesting topics, and thereby mapping larger organisational "chunks" rather than finalising each step at a time. It is important to allow for the thoughts to drift,

and the discussion to move more iteratively from one topic to another – the meeting leader has his own map to fall back on, when the process need to proceed.

The last item on the agenda was the documentation of the result, which consisted of photographing the white board and thereby allowing for turning back to each of the problems, and their context at a later time.

During the session, we noticed us the following advices, which in a future situation might help easing the process.

A good idea is to use different colours for the different elements on the white board, as it later is much easier to distinguish between structure, flows and text. Another tip is to use a *very* large white board as the map has a tendency to become very rich, and thus including very much detail and data – and it is much more difficult to embrace a white board very crowded with drawings at one glance. Leaving space between the different drawings makes it easier to avoid moving parts of the drawing, which can be quite problematic, when the process is well underway – it is difficult to make certain that all flows are moved along, and it can be very difficult to re-connect a flow later, if nobody remembers exactly what this flow represented.

We did not provide the flows with descriptions of what they represented, but this might be a good idea, if some flows proves to be more interesting, and thus the subject for a more thorough examination. By labelling the flows it is also possible to verify that the same flows are not represented twice in the map.

6. Results

Having described the technique, and how it was applied in the organisation, we will in this section classify the different elements of the map that proved especially useful when comes to the analysis.

We describe here one overall effect resulting from the mapping process and four distinctive categories of critical situations which the maps makes it easier to point out, and which might cover a problematic situation.

6.1 Communication and consensus

A primary result from our analysis is the broader understanding it provided the participants of the session. This, we believe, has a not negligible therapeutic effect when comes to the understanding of other peoples understanding of the system or in this case the organisation. When the participants are presented with other viewpoints than their own, they have to reflect upon these, and this will have an impact upon how they see the world, and thus providing them with a better ability to understand the situation from other perspectives in the future. This should ease the mutual understanding between different areas of the

organisation, making it even easier to communicate in the future – and thereby also easier to solve current problematic situations and improve future practices.

6.2 Hubs

Even in a complex map some characteristic situations can be rather easily spotted. One such is a specific individual or organisational unit who or which have a large number of connecting knowledge flows with the rest of the organisation. Around such a knowledge centre or "hub" much knowledge flows, making it an important part of the organisation.

In our case i.e. one person had several roles in various parts of the organisation, which showed in the map as many flows leading to him. As the matter of fact this person had so many roles, that we needed to draw him several places on the whiteboard to avoid having too many arrows crossing over the elements surrounding "him". So we invented a symbol representing this individual making it easier to identify him in the map.

A hub might be a useful thing to have in an organisation, if it can cope with the knowledge flowing to and from it, and can effectively use this information, but too many flows ending in one place might easily create congestion and thus a hub might end developing into a bottle neck slowing (or discharging) information, and this way become a hindrance for the organisations ability to share knowledge.

6.3 Black Holes

Black Holes we use to describe place in the organisation where no flows origin. This means that knowledge only flow one way towards this area, and nothing returns. Again this might not be problematic, if no feed back from a specific part are needed, but it might also well represent a situation, where an organisational unit are drifting away from the organisation. As argued above, learning from experiences is an important part of the organisational development and improvement, and when specifics part of the organisation are not feeding these experiences back, it is not possible for other parts to learn from their successes and failures. An example from our study showed that some developers did not know where to go to with their suggestions and experiences, and these were therefore lost for the organisation.

6.4 Springs

Another identifiable situation on knowledge maps is the areas from where lots of flows origin but no are returning. These "springs" might indicate potential innovative centres where lots of ideas are created and exported to the rest of the organisation, which can be used both as a source of innovation, and as a source of communication. The learning from experiences approach is a knowledge

exploiting approach , which helps the organisation become expert in its field because it will continuously be able to learn from both successes and failures. On the other hand this approach include the danger of the organisation becoming "skilfully incompetent" i.e. so specialised that it can not react (fast enough) to changed conditions e.g. changes in the market . Locating springs can be a means of supplementing the exploitation approach with a *explorative* approach, by being able to point to the places in the organisation, where radically new ideas grow, and to where new initiatives are most like to diffuse from.

A spring might also point to an area which is not using others experiences in their planning. This is not necessarily a problematic situation, as it can represent a highly specialised unit, which does not need any knowledge input, but it might as well point to a potential problem, which should be analysed further.

6.5 Missing Links

Missing links are more problematic to spot in a knowledge map. The term is used to describe a situation where a link would be feasible for the organisations a whole, but for some reason is not present or not functioning satisfactory.

Similar organisational units might achieve from having a close dialogue since their practises might be similar as well, thereby allowing them for having a relatively high outcome of sharing their experiences, and if no knowledge flow exists between these units, a potential benefit might be lost. Other parts of the organisation might have other needs for connections, which can be sought out in a map, and addressed if not present or not considered providing the expected outcome.

7. Discussion

In this setting the knowledge mapping technique provided both the organisation and the researchers with useful results, but it is of course no guarantee for success. An important factor which facilitated the success of the mapping technique in this setting was the fact that the researchers have been present in the organisation for a long time in advance of the actual mapping session.

This means that the members of the organisations know the researchers well and a trust relationship exists. The trust is important when comes to the discussion of delicate and confidential information and an open-heartedly atmosphere is one crucial pre-requisite for a successful outcome. If the participants feel that they can not address all aspects of the organisation, and are afraid that some issues are not to be discussed, then the map and the mapping process will be amputated and critical areas overlooked.

Besides this "opening-the dialogue" effect, the researcher's being present in the organisation over a long period of time, means that the discussion will flow more easily. By having cooperated with employees and participated in meetings and informal activities, the researcher has been able to understand of the culture of the organisation. This means that the researchers know to common elements of the organisation, the artefacts, the language, the development projects, the tools used etc. During the mapping process the organisational members then do not have to explain all organisational specific (and taken for granted) concepts, and thus the conversation can flow more easily and focused. The basic understanding can also be used proactively by the researcher because it makes him able to oversee the larger picture, and therefore makes him better at combining various elements in (or not in!) the map. On the other hand the conception of having a good understanding of the organisation can turn out to be wrong – and then the misconception can lead to misunderstandings – because the participants in the mapping process - without knowing it – are having different understandings of the same concepts.

A critique of our approach could be that no actual project participants were present during the mapping session. This would have provided the mapping with direct data from the projects. As it was carried out only researcher and the SPI-team were present, which provided the session with secondary data only (when dealing with project work). The same critique can be rephrased as the technique relies heavily on the ability to address all relevant involved personel – if this is not possible we will get a distorted picture of the organisation, which very well can be a cause of misinformation – the practice in the organisation is often differing from the "official picture" , so management alone most likely cannot build a adequate map.

A way to avoid this would be to involve more employees in the mapping session, allowing them to bring forward their interpretations of their situations, but this also introduces the use of more resources during the mapping process, and it heightens the complexity of the process, which of course will enrichen the picture, but also make it more difficult to comprehend. In this case the low number of participants where chosen partly because of the resources, but primary because the researchers wanted a smaller forum to test the technique in.

Another consideration about this approach is the use of rich pictures. Pictures can be easy handled by some whereas others have no problems drawing and discussing via pictures . This is why it is important to facilitate the use of pictures i.e. by letting a meeting leader do these drawing the first time the technique is used. In our case the researchers (who all had tried drawing rich pictures before) were present and thus could explain and consult the other participants in the technique.

7.1 Further research

A direct outcome of the mapping technique has been a considerable focus on the development projects capability to share their experiences – be them successes or failures – with the rest of the organisation. This has led to the implementation of a new project evaluation concept which strengthens the feed back mechanisms in the projects and simultaneous facilitates the diffusion of formal Knowledge Networks (KN). In this way the new concept is intended to letting the experiences gained in the projects into the KN's and at the same time make the accumulated knowledge from the networks available for the projects.

This new project is currently being developed and implemented in the organisation in a close collaboration with the researchers.

8. Conclusion

In this paper we describe how we in a close collaboration with Danish software company analyses its organisation looking for relevant improvement possibilities.

We develop a knowledge mapping technique based on using rich pictures as a mapping tool, visualising the relevant organisational units, individuals and artefacts, and their mutual communication streams or knowledge flows, including the context surrounding these flows.

We use a range of qualitative data gathering methods conducted through out a ten months period to inform the application of the mapping technique in the organisation.

We conclude that this technique can provide a helpful means in the understanding of the complex scenario which a software company with many simultaneous projects constitutes, because the technique is showed to produce valuable results for the organisation with respect to providing it with information about where improvements could be relevant.

The specific setting and technique thus proves useful in this research project, and provides the organisation with valuable feed-back, but the same setting might not lead to the same success in another organisation or with other participants. We do not claim this technique to be a silver bullet for creating improvement initiative candidates in every context, but by reporting our experiences we are adding to the already existing body of knowledge within the field. We hope that our contribution can inspire others in their research or practical improvement work, and thus providing the SPI field with better tools.

9. References