Managing and Processing Knowledge Sharing between Software Organizations: A Case Study

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Abstract--Knowledge sharing increases the knowledge capital of every organization, and thereby its competitiveness. The goal of collaboration and knowledge sharing is to generate additional value for the organization. The prerequisites in this issue such as collecting, absorbing and applying new information and new knowledge are paramount, especially in knowledge-intensive organizations where intellectual capital is the most important asset. In this empirical case study, we describe a method for managing and implementing this knowledge-sharing process between software organizations. We also analyze and discuss the factors observed, which seem to affect success when trying to collect and share information between individuals or organizations. The results give empirical information for management when they try to find ways to manage and solve knowledge management issues. In addition, we briefly present a knowledge-sharing management tool under development for delivering the knowledge; collected and shared, back to the software organizations for utilization in their software development processes in order to make their business more effective.

I. INTRODUCTION

Success in today's information-driven and knowledge-based business environment necessitates both fruitful collaboration and knowledge sharing with other organizations. In this paper we present a way to implement collaboration in the knowledge-sharing process between software organizations. The aim of this study is to give an example of how knowledge management can be organized between organizations in practice.

In today's competitive environment an organization's success depends, maybe more than ever, on its ability to create and share knowledge effectively and efficiently [8]. To overcome issues caused by increased ambiguity, relevant knowledge and high quality information have become the most valuable resources of every knowledge-based organization [14]. Especially in knowledge-intensive organizations like software companies, increasing knowledge capital through collaboration makes the organization more competitive [3][26]. In the software business, information sharing and collaboration with other companies, usually also competitors, is a lifeline to business but is not always so easy to realize [2][18][20]. In this paper we describe an example of how to manage and collaborate on this essential but challenging topic.

The basis of this study is an ongoing research project with the aim of developing a web-based *KM tool* (knowledge management tool) for enhancing knowledge sharing between software companies. In this project we are trying to find and pilot a sensible way to collect and share information and experiences between software organizations. The participants in this case study consist of Finnish software companies and two Finnish universities, the Tampere University of Technology (TUT) [24] and the University of Joensuu, (UJ) [27]. The project is funded by Tekes (Finnish Funding Agency for Technology and Innovation) [25] and the Finnish Software Metrics Association (FiSMA) [10] and coordinated by the participating universities. The reason for developing such a tool is based on research that indicates that investments in information technology applications and the systems, which support knowledge sharing, affect positively the personnel's capability to share their own knowledge [16]. Generally in data systems, one can only store explicit knowledge and if knowledge sharing between organizations concentrates only on this information, it leaves out all the social and dynamic dimensions of knowledge [13][23]. Therefore our focus was on finding a mechanism to gain a lot of empirical knowledge for this KM tool and also to evaluate and discuss together the information and knowledge obtained before sharing it via the tool. In this paper we describe the method used for this process and also discuss the main observations of this empirical study. We also briefly evaluate the usability of this tested method and its suitability for the research subject and give some suggestion for future work.

The structure of this paper is as follows: Chapter II describes first the background of the study. In Chapter III, we introduce the phases of the created model for knowledge management. Next, in Chapter IV, we deal with the main observations and issues encountered when executing this process in practice and also evaluate the usability and appropriateness of the created model itself. Finally, in Chapter V, we sum up the case study and draw conclusions from the research.

II. BACKGROUND OF THE STUDY

In this chapter the context of the topic in this study is presented in brief. First in section A, the main principles and definitions of knowledge management are described and then, in section B, some background of the selected case study.

A. Knowledge management – a significant part of a knowledge-intensive business

In the network economy, which is typical in today's information society, the ability of organizations and their members to cooperate, interact and share their information and knowledge is a prerequisite for strategic operation [14].

In practice, this ability necessitates collaboration among its interest group. The company must create a co-operation relationship with other organizations and try to increase its own learning and knowledge by utilizing the knowledge sharing which occurs in this intercourse [26]. The purpose of this is to reduce the uncertainty of the operational environment by ensuring that the company has the possibility to access wider knowledge of the business environment. Knowledge sharing, which is a consequence of this kind of collaboration, increases the knowledge capital of every organization and, thereby its competitiveness. In short, we can say that the goal of collaboration and knowledge sharing is to generate additional value for the organization. Precisely these two factors, collaboration and knowledge sharing, were the main elements when we planned and built our research framework in this case study.

In Figure 1 we can see the theoretical framework of knowledge management. Knowledge management (KM) refers to the activities involved in discovering, capturing, sharing, and applying knowledge. KM processes are meant to help the activities. The processes are supported by KM systems, which are the integration of technologies and mechanisms. KM sub-processes (such as combination, socialization, externalization, internalization, exchange, direction, and routines) facilitate the broad processes. KM systems rely on a KM infrastructure [1].

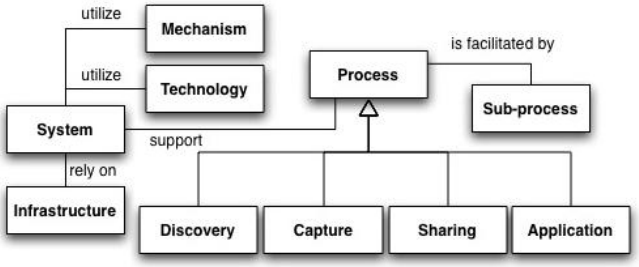

Figure 1. The concepts of knowledge management (Berecca-Fernandez et al.2004) [1].

To put it simply, we can state that knowledge management is a matter of improving conducive ways of thinking, practices and developing support systems to promote knowledge sharing. Knowledge sharing, which is one of the key issues in this study, is one prerequisite for creating new knowledge and organizational learning. In this study our aim was to examine, develop and test the way of executing and managing the sharing process, especially from two different viewpoints: capturing information and sharing the captured information.

B. A case study – the SoMe project

The research is based on issues observed in relation to software process quality. Shared information, in this case, concerns software measurement, which is quite a challenging field in software development. The topic is based on the perceived need for improved measurement knowledge in Finnish software companies [11]. In practice, it has proved difficult to define the key functional process and product measurements and many software companies have found measurement to be a challenging and problematic task [3][9][26]. To promote a better understanding of measurement and to offer a robust and pre-selected set of metrics suitable for different kinds of business goals, FiSMA initiated the SoMe (Software Measurement) project in autumn 2005 together with Tampere University of Technology (TUT) and the University of Joensuu (UJ). FiSMA itself is a non-profit making organization created to promote the usage and utilization of software measurement to improve the quality of processes and products. Its members, and also the participants of this study, consist of nearly 40 Finnish software companies, plus several universities and other public organizations. In the context of the SoMe project, we are studying different tools and practices to help solve the measurement problems related to the quality of both software process development and software products [22]. The aim of the SoMe project is to develop, in cooperation with the participants, a common and open measurement system for Finnish software companies to help monitor and measure the quality of their software processes and products. The final outcome of this project is a knowledge-sharing tool to be implemented in a web environment based on a large metrics database. The final database will consist of three different types of information (practical experience, literature and standards), but in this paper we will not handle its detailed structure or content. The complete KM tool will utilize a web-based repository of best practices as the technology. In this study our focus is to describe how the information-sharing process was executed in practice.

III. THE METHOD FOR CAPTURING AND SHARING KNOWLEDGE BETWEEN ORGANIZATIONS

In this chapter we describe the steps of the method used in our study. First in section A, the knowledge-capturing phase is described, then section B concerns the analysis and organization of the captured knowledge. Thirdly in section C, we describe the collected and modified information evaluation process and finally in section D we give a short presentation of the final KM tool and its utilization. Figure 2 describes the process of how the knowledge was captured, modified, evaluated and shared.

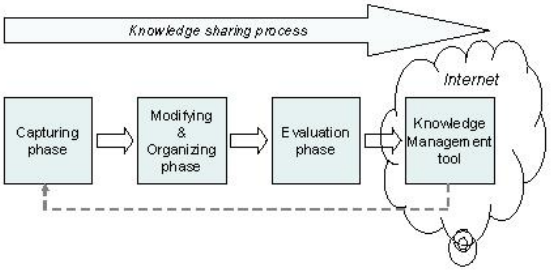

Figure 2. The phases for capturing and sharing knowledge.

A. Capturing knowledge

This part was an empirical study, based on interviews and a questionnaire format. The knowledge required has been captured from the participating organizations through externalization using face-to-face meetings and the data collection form as the mechanism. The target group inside the company was that of quality managers, who are typically responsible for measurement operations and the metrics used in practice. Our method was to conduct interviews to address the research questions. We used the same structured interview templates in all interview sessions: one form to collect general information about the company and its measurement practices, and another spreadsheet-style form, which provides the basic data for this study, to collect all the process metrics the company uses or has used (see Appendix A). The aim was to give as explicit a description as possible for all the process metrics used in the participating companies. We also made notes on our discussions relating to the experiences and practices in the subject matter which were reported later.

B. Analyzing and organizing the collected knowledge

After the capturing phase, the collected information was combined and organized by the authors. The information captured must be pre-evaluated and analyzed as to its suitability, usability and the correctness of the examined topic. Among the data there could be some duplication or information which is not strictly relevant, and therefore we pre-evaluated the information obtained, and combined or left out all those that were out of our research scope. Also information without sufficient description as discarded. Alongside this elimination work, we categorized, classified and outlined the knowledge obtained on the database, to help control and maintenance work of the system. The captured knowledge must also be modified in the same framework with the help of research. The metrics database under development consists of individual items, *knowledge items,* of information and the manifestations of these items are the metric documents. The formula for the title level and the terminology used in all documents is congruent with others. This solution helps the end user to read, perceive the logic and make a comparison between the knowledge items.

C. Evaluating the collected knowledge

In this section we describe the procedure how the knowledge-evaluating process was executed in practice. Before distributing the captured and modified knowledge classified by the authors via the developed KM tool, our target was to evaluate the applicability and intelligibility of the shared information together with representatives of the participating companies. In our case, as explicit information systems in general, the most essential part of the KM tool is the content of information, which is stored therein. As is also known, data systems can create a collaborating network structure, but they do not necessarily support and give rise to social interaction [5]. Based on this information, the project established a support group inside FiSMA. The aim of this practice was to evaluate the knowledge collected with the end users before placing it in the KM tool and delivering it to the organizations. All the companies in the scope can take part in these regular support group meetings. The objectives of the group are, firstly, to evaluate the knowledge collected and stored in the developing KM tool and to test the tool in practice; secondly, to provide a forum to promote collaboration and communication between the members; and thirdly, to help manage the project. The basis for establishing this support group was the fact that if a company or person can be part of a project from the outset, the participants feel and see that they have influence on the project. This will in turn increase the motivation to share their knowledge during the project. This support group also provides ideas, feedback and criticism on the work produced and also evaluates the collected, modified and presented content of the knowledge as well as the structure and usability of the KM tool itself. Related to our development project of the KM tool, we must also take into account the fact that if individuals are not motivated to share knowledge, it is unlikely that they will be motivated to use tools to facilitate knowledge sharing. This is one of the main reasons to carry out personal interviews with participants and also to arrange many support group meetings in this knowledge-sharing project.

D. Sharing collected knowledge – a KM tool

A very important element in the knowledge-sharing process is the instrument which is used for delivering the knowledge. In this case study, our target is to create a web-based application to realize the outcome of the project. The final outcome will be a measurement knowledge based KM tool, consisting of a large metrics database where all the collected knowledge, knowledge items, were stored and structured. The applications development work is being carried out by the authors with the close co-operation of the project support group. This collaboration helps the developers to take the end users' viewpoints into account during the development work and guides the building of the user needs oriented application tool.

The user interface of the web-based KM tool is built so that there is a search-taxonomy which guides users to choose the proper metrics depending on the selected process assessment models (SPICE, for Software Process Improvement and Capability dEtermination [15] or CMMI, Capability Maturity Model-Integrated [7]). The purpose of this approach is to guide and familiarize the user in using and understanding the structure of these two widely known process assessment models which are closely related to and an essential part of the research topic of the project. In addition, there are possibilities of making a search according to the purpose of the measurement (description, monitoring, control, prediction, validation) and there is also a word-search feature meant for beginners. Users can search for meters that fit their organization's practices, or find meters related to the type of their current projects, or check out suitable metrics

related to certain processes. The application is primarily meant and designed for those responsible for software processes or products quality, but its usability also takes into consideration other users from developers to top management. The main purpose of the KM tool is for software companies to obtain information for different metrics and their applicability to measuring different processes for all levels.

In order to intensify and accentuate the knowledge-sharing feature of the KM tool, we added to it some characteristics which allow interaction between the tool and the user. This extra functional approach for the individual users allows them to communicate and cooperate with other users and administrators. This creates a line of communication between companies, allowing them to share knowledge and learn from others. The function also operates as a feedback channel during the development work for system developers. The KM tool will be released together with its support systems at the end of the project in April 2007.

IV. DISCUSSIONS AND OBSERVATIONS

The analysis presented here highlights some general observations on the results of this case study. In this chapter we present the main points which came up during the above phases. These analyses are based mainly on the participants' behavior observed in the empirical part of our study. These observations give empirical information for management when they are trying to find ways to manage and solve knowledge management issues. One of the main starting points when planning this knowledge-sharing project and its output, the web-based tool, was to connect the participants in this study at the very outset and make close co-operation with them all throughout the project. Our assumption was that this procedure would help us to realize knowledge-sharing process itself with the participants and also to ensure the appropriateness of the final outcome, the web-based KM tool. With hindsight we can state that this was a good choice of starting point for a study in practice too.

In the interview phase we tried to observe the interviewee's motivation to share or withhold information on the issues in question. This is because motivation factors for individuals can significantly affect their desire to share their knowledge with others [19]. In addition, when developing a new tool we must take into account the fact that if individuals are not motivated to share knowledge, it is unlikely that they will be motivated to use tools to facilitate knowledge sharing [12]. During the interviews we observed that there is both a need for and a lack of measurement information. This combination seemed favorable, and supposedly motivating, for knowledge sharing at least in this case. Our assumption was that this situation affects a company's and an individual's willingness and openness to share their knowledge. This observation confirms the research results obtained by Kollockin et al. [17]. Moreover, in this project we did not collect measurement figures themselves. Instead we were interested in collecting practices (measurement objects and metrics) and experiences related to utilizing measurements in software engineering. This policy may have a positive effect on sharing knowledge between organizations. We assumed that this approach would help us to increase the trust and openness felt by the participating firms. These aspects are recognized enablers for the knowledge-sharing viewpoint [4][8]. Related to this, it seems that the Universities have a strong influence and prestige in software companies and persons interviewed were very open and trusting of us as researchers.

The persons selected to be interviewed, in this case, were people who had experience, knowledge and understanding of the research topic or measurement within their respective companies – mainly quality managers. During the interviews we observed that there is often only a few or just one person in Small and Medium Size organizations (SME) who deals with issues concerning organizational knowledge. This general observation could be one reason which encourages a person to participate in sharing information and also to take part in the arranged collaborative discussions on the topic (i.e. support group meetings). It also supports Hendriks' [12] findings that the key to success in knowledge sharing is that the personal ambition should match the group ambition. He states that a person is more willing to give and share knowledge if she notices that they share similar interests and if they speak the same "language" (jargon, technical terms, etc) as other people. In addition, Brown and Duguid and [6] present that there is a parallel between knowledge-sharing behavior and other social cooperation situations. Based on this finding, we decided to use a research method focusing on personal interviews and support group meetings at regular intervals with participants instead of a pure questionnaire.

In the support group meetings the project participants learn in practice to know each other and to discuss issues related to software measurement openly. This also corroborates previous assumptions that the sharing and absorbing of knowledge is easier between persons who are on the same level of abstraction [21]. It seems that people experienced knowledge sharing as a beneficial factor for their own work and saw it as positive that other people were also interested in the same things as they were. With these support group meetings, the researchers can test and evaluate the knowledge captured and modified by them with the participants. They can evaluate the presented information from individual knowledge items to the whole structure of the KM tool created during the development process. This proved to be a good practice when finalizing the information to be shared and especially when building the user interface for the web-based tool. This steering group also provides important information and feedback for researchers to develop the KM tool in the right way. These meetings and discussions are also motivating for the researchers during this long project.

Finally, an interesting topic observed for future research. It would be interesting to examine if and how the subject

matter may affect the knowledge-sharing situation. One can sense among the participants a very positive attitude toward knowledge capturing and sharing of the research topic. They seemed to be happy to provide information about issues that they had not fully mastered themselves and which was also an internal development matter. Most of the interviewees were quite insecure about their own expertise. One reason for that, in this case, could be that most of the measurement models and metrics used are often "home-made". Therefore our assumption was that there must be a lot of pressure to make sure that they are acting in the right and relevant way and to benchmark other firms' measurement procedures. If a company or person has the complete, confirmed or even correct information in the current situation, the motivation to participate in this kind of research will be boosted. In this case study precisely this aspect, the subject matter, could be one of the significant issues which may affect a person's willingness o share knowledge with others. For future work it would be interesting to make some comparisons by trying to capture different types of knowledge using this knowledge-sharing model. That could give us information on whether and how significantly the subject matter may affect the person's willingness to share their knowledge.

V. CONCLUSIONS

In this paper we present a model of how captured and shared knowledge can be transferred between software companies. Our aim was to examine how to realize the collection and sharing of knowledge between organizations in practice. In this case study we examined, developed and tested the method of executing and managing this process. The basis of this study is an ongoing project with the aim of developing a tool for enhancing knowledge sharing between software companies. The primary focuses of the project were to find a mechanism for gaining empirical knowledge involved in the knowledge-sharing tool under development, and also to find a method which can help improve collaborative knowledge sharing between software companies

Based on the experiences of this empirical case study we analyzed and discussed the main observations and issues that arose related to this knowledge-sharing model development process. During the interactive sessions with participants a lot of interesting individual issues and factors arise which may affect a person's willingness to share knowledge with others and also his or her willingness to take part in the knowledge-sharing process. The created and tested knowledge-sharing model, including a web-based KM tool for executing the sharing, seems to be workable and achieved the goals which were set for it. It enabled the desired knowledge to be shared, which included in this case knowledge captured, stored, evaluated and delivered back to the organizations and persons who volunteered the information. This approach is very close to the main concept of knowledge sharing, one of the most important elements in the knowledge management framework. The model developed seems to be relevant to the process of collecting and sharing knowledge to be part of a knowledge base. The results give empirical information for management when they try to find ways to manage and solve knowledge management issues. One theme for future work could be to examine, using our model, if and how the subject matter can affect the motivation and interest in collaboration in knowledge sharing. Did we achieve these results because of the model used or was it because of the subject matter of the case study?

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APPENDIX A

Spreadsheet-style interview form for collecting detailed metrics information.

	A	B	C	D	E	F	G	H
1	#	**Name**	**Purpose**	**Type**	**Target**	**Application Domain**	**Formula**	**Values**
2		*name of the meter*	*extensive description of the meter and its purpose*	*meter's type: Monitoring, Controlling, Predicting, Validating*	*what attributes of product, process and/or project are measured*	*in what processes, lifecycle phases etc. the meter is used*	*how the meter is calculated*	*values the meter produces and their interpretation: what's good, what's bad, what's preferred*

	I	J	K	L	M	N	O	P
1	**Data 1**	**Data 2**	**Data 3**	**Data 4**	**Data Collection Rate**	**Primary Collectors**	**Secondary Collectors**	**Usage**
	data used to calculate the meter	*data used to calculate the meter*	*data used to calculate the meter*	*data used to calculate the meter (add more columns if needed)*	*how often the data is collected (e.g. X times in a day/week/month/other, please specify)*	*who are primarily responsible for measuring or for collecting the data*	*who are secondarily responsible for measuring or for collecting the data*	*how the data is collected and the metric calculated*

	Q	R	S	T	U
1	**Examination Rate**	**Primary Beneficiaries**	**Secondary Beneficiaries**	**Workload in Establishing the Meter (1)**	**Workload in Establishing the Meter (2)**
2	*how often are the meter's results looked at (e.g. X times in a day/week/month/other, please specify)*	*who are primarily using the meter's results*	*who are secondarily using the meter's results*	*how much resources are consumed when the meter is first introduced and established (e.g. person-hours, calendar time etc.)*	*estimation of the workload; scale: 1 = heavy, 2 = considerable, 3 = moderate, 4 = light*

	V	W	X	Y	Z	AA
1	**Workload in Using the Meter (1)**	**Workload in Using the Meter (2)**	**Accuracy**	**Reliability**	**Risks**	**Usefulness**
2	*how much resources are consumed when the meter is used (e.g. person-hours, calendar time etc.)*	*estimation of the workload; scale: 1 = heavy, 2 = considerable, 3 = moderate, 4 = light*	*estimated accuracy of the meter's results; scale: 1 = inaccurate, 2 = approximate, 3 = quite accurate, 4 = very accurate*	*estimated reliability and robustness of the meter's results; scale: 1 = unreliable, 2 = moderate, 3 = quite reliable, 4 = very reliable*	*risks and problems related to the meter's usage*	*general estimation of the meter usefulness; scale: 1 = useless, 2 = of limited use, 3 = quite useful, 4 = very useful*

	AB	AC	AD	AE	AF
1	**Other Information**	**Source**	**References**	**Author**	**Web Links**
2	*free-form notes, comments and other information (e.g. meter's relation to various process models; to different sizes and types of projects or organizations; etc.)*	*source of the meter, any of the following: Literature, Organizations, Standards*	*detailed sources of the meter: - name of the author and book/article/web site/etc. - name of the company or organization - name of the standard or model*	*name of the author who has written the information about the meter in this table*	*possible links to WWW sites with related information*