Impact assessment of knowledge sharing bottlenecks: the Knowledge Sharing Environment Model (KSEM)

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Abstract

Knowledge sharing is a critical phase of the Knowledge Management life-cycle since it is an important precursor to the actual usage of knowledge. Knowledge initiatives to improve knowledge sharing requires an analysis of current knowledge sharing processes to identify bottlenecks that hinder knowledge sharing processes. Current knowledge auditing techniques for assessing knowledge sharing problems in organizations are insufficient in addressing the specific knowledge context of particular business functions. We propose a new technique the Knowledge Sharing Environment Model (KSEM), to model the knowledge sharing environment of specific business functions that helps in identifying the impact of bottlenecks in such environments.

Keywords

Artefact Networks, Knowledge Audit, Knowledge Management, Knowledge Sharing, Social Networks.

1. INTRODUCTION

The term Knowledge Management (KM) emerged in the late eighties and involves the management of knowledge processes in the organisation, i.e. creation, sharing, application and evaluation (Alavi and Leidner, 2001, McElroy, 2003, Teece, 1998). The ultimate goal of KM is to optimally use the intangible assets of an organisation, i.e. its knowledge embedded in structures, systems, people and relations, in order to achieve competitive advantage (Davenport et al., 1998, Davenport and Prusak, 1998). This thinking about knowledge assets resulted in a shift in strategic management thinking from the resource-based view of the firm to the knowledge-based theory of the firm (Grant, 1997, Grant and Baden-Fuller, 1995, von Krogh and Roos, 1996).

Within the field of knowledge management, knowledge sharing has received much attention (Borgatti and Cross, 2003, Dixon, 2000). Sharing of knowledge is an important step before its actual use - only if knowledge flows through the organisation will it reach the people that ultimately need that knowledge in their day-to-day business activities. There are different solutions for improving knowledge sharing within organisations and the origin of these solutions can be traced back to the notion of explicit and tacit knowledge from Polanyi (1966) and Ryle (1949). One category of solutions assumes that knowledge can be made explicit and therefore be stored and shared through knowledge bases. Another category assumes that knowledge is tacit, inherently personal, and cannot be codified (Hansen et al., 1999). Sharing of tacit knowledge is mainly done through socialisation, which means interaction between individuals to transfer knowledge by means of rules of thumbs, war stories, or collaborative problem solving through active knowledge transfer techniques (Leonard and Swap, 2004).

KM initiatives to improve knowledge sharing typically start with an assessment of the current situation. The problem here is to get a good overview of the current knowledge sharing processes, bottlenecks in these processes that hinder knowledge sharing effectiveness and efficiency, and finally how to prioritise the knowledge sharing bottlenecks (Levantakis et al., 2008). One approach often used in this respect is conducting interviews to sketch the knowledge processes and distil bottlenecks from the interviews. However, we feel that such techniques insufficiently address the specific knowledge context of particular business functions. Therefore, we developed a new technique: Knowledge Sharing Environment Model (KSEM), to model the knowledge sharing environment of particular business functions and aid in identifying bottlenecks and, their impact. These impacts then help to prioritise knowledge sharing bottlenecks and hence guide knowledge management initiatives that aim to improve knowledge sharing efficiency and effectiveness.

Our research follows a design science research approach to develop the KSEM technique. In this approach we embedded a case study at a product software developer to evaluate our technique in terms of correctness, completeness, ease of use, and practical value for the organisation. The next section describes related work on knowledge auditing methods, while Section 3 introduces the Knowledge Sharing Environment Model. Section 4 elaborates on our research approach while KSEM is applied to a case study and evaluated in Sections 5 and 6 respectively. Finally, conclusions of this research are presented in Section 7.

2. RELATED WORK

Within the domain of Knowledge Management, the field of Knowledge auditing is related to our work. Knowledge auditing is considered to be a successor to information auditing, and can determine what knowledge an organization has, the sources of knowledge, locations where knowledge is stored and how it is used. Several authors have suggested methods for conducting knowledge audits, including Liebowitz et al. (2000), Burnett et al., (2004), Iazzolino and Pietrantonio (2005), Perez-Soltero et al.(2006), and Cheung et al. (2007). Levantakis et al. (2008) created a reference method for Knowledge Auditing by synthesizing 13 knowledge and information audit methods. Informed by Method Engineering theory (Brinkkemper, 1996), this new method constitutes 8 main activities namely: preparation for the audit, promotion of the audit's benefits, investigation of the targeted area, data collection, data analysis, data evaluation, conclusion of the audit and re-auditing.

The knowledge audit process typically makes an inventory of existing knowledge and knowledge processes in the organization and assesses whether there is a gap between the current and the desirable situation required to achieve business goals (Levantakis et al., 2008). From this gap analysis it becomes clear what knowledge the organization has, i.e. its knowledge inventory, and what knowledge is lacking and should therefore be acquired or developed. Furthermore, it becomes clear which knowledge is out-dated and should be divested. Although the gap analysis is a starting point in many knowledge audit methods, this analysis is often extended to a more elaborate analysis of knowledge processes. One example is the knowledge map, which indicates who possesses what knowledge (Burnett et al., 2004, Perez-Soltero et al., 2006). Another example is an analysis of the knowledge flow within the organization using social or knowledge network analysis (Cheung et al., 2007, Helms, 2007). Another approach is taken by Van der Spek et al. (2002) who developed the so-called 'Knowledge Strategy Process' which aims to create more focused KM initiatives that are aligned with organizational strategies and relevant business drivers. The Knowledge Strategy Process combines three techniques into 6 process steps that result in a KM action plan. The 6 steps include the following: a clear description of the business case, identification of knowledge areas relevant to the business case, identification of important Key Performance Indicators (KPIs) based on the business case, analysis of the knowledge areas in terms of current and future impact on the KPIs, assessment of the knowledge areas in terms of proficiency, codification and diffusion and finally a description of a KM action plan. Even though the Knowledge Strategy Process is not labelled as a knowledge audit, its overall aims are similar to those of Levantakis et al. (2008) in the sense that both approaches attempt to identify key steps towards improving KM initiatives in organisations.

Analysis of the knowledge auditing methods reviewed by Levantakis et al. (2008) learned that these methods mainly rely on interviews for revealing bottlenecks with respect to knowledge sharing. However, interviews do not provide much structure to analyse knowledge sharing in a consistent way. For this purpose, the Knowledge Sharing Model from Bosua and Scheepers (2007) was found useful since it more precisely identifies the required elements that need to be in place for effective and efficient knowledge sharing. According to this model, key elements that contribute to effective knowledge sharing are: mature informal and formal social networks (SNs) and a shared artefact network (AN). Accompanying Facilitating Mechanisms in SNs (e.g. Communities of Practice, knowledge roles, mentoring and incentives) and ANs respectively (e.g. information and knowledge classification schemes to manage and structure content) contribute to the efficiency of knowledge sharing. However, this model lacks a mechanism, as we found in knowledge auditing methods, for prioritizing knowledge sharing bottlenecks.

In this research we used the model by Bosua and Scheepers (2007) as a basis for developing a new technique that is able to identify and prioritize knowledge sharing bottlenecks in a more structured way. This technique could well be integrated in existing knowledge auditing methods were a more detailed focus on knowledge sharing is required.

3. RESEARCH APPROACH

This section describes the research approach that has been applied. It concerns a Design Science Research (DSR) approach in which a case study is embedded to evaluate the artefact resulting from the DSR approach. The case study company is the same company in which other parts of the research took place. This section starts with an introduction of the research site, followed by details on the DSR approach and ends with the evaluation case study set-up.

3.1 Research site

The research was conducted in the Netherlands in the Spring/Summer of 2008 at Unit4Agresso, a product software developer that develops integrated business applications for different industries. Its headquarters is located in The Netherlands and they operate in 10 European countries, the United States, and Canada. Furthermore, there are several re-sellers, amongst others in Australia. At the end of 2008 the number of employees at the company has risen to about 3,500 and the net-turnover was approximately 400 million Euros. The research itself focused on one of the software product development lines of the company. A software product line can be seen as a small software company that is responsible for all aspects of software development such as requirements formulation, development, testing, release, implementation, and support. The particular software product line in this study develops software for the Wholesale & Distribution sector and employed 99 people at the time of conducting the research.

3.2 Design science research

As indicated in the previous sections already, the main goal of the research is to develop a technique to identify and prioritize knowledge sharing bottlenecks. For this purpose a DSR approach is used - now a commonly accepted method in the field of Information Systems research. The philosophy behind DSR is that new scientific knowledge can be generated by means of constructing an artefact (Guba and Lincoln, 1994, Peffers et al., 2008, Vaishnavi and Kuechler, 2007, Hevner et al., 2004). In this case, the artefact is the modelling technique called Knowledge Sharing Environment Model (KSEM). The steps in developing the technique according to a DSR approach, following Vashnavi et al. (2007), are described below. Steps that are very similar to the DSR approach as described by Peffers et al. (2008).

Problem awareness: Awareness of the problem was raised during contacts of the researchers with a product software company, i.e. the company mentioned above, that was struggling with knowledge sharing in their organisation. A research project was started to help this company improve their knowledge sharing and one of the first steps concerned making an inventory of potential bottlenecks that negatively influence knowledge flow. The existing literature was consulted to find techniques to support the identification of bottlenecks (see section 2). This resulted in the awareness that a technique was lacking to identify and prioritize bottlenecks in a structured way.

Suggestion: In the literature we came across the Knowledge Sharing Model of Bosua and Scheepers (2007), see also section 2. Their work demonstrated that it could be used to identify knowledge sharing bottlenecks to some extent. The elements of the model, including shared work context, social network, artefact networks and facilitating mechanism seemed to provide a guideline for conducting interviews to reveal knowledge sharing bottlenecks. Therefore, it was decided to use this model as the basis for the research project at the product software company.

Development: During the first interviews at the company we started with the Knowledge Sharing Model as a basis. Applying the model in practice revealed in new insights concerning the identification of knowledge sharing bottlenecks, which eventually resulted in the Knowledge Sharing Environment Model that is presented in section 4. Finally, this field experience also lead to the idea of calculating the impact of knowledge sharing bottlenecks, which can be used to prioritize bottlenecks.

Evaluation: Based on the experience from the interviews, we developed the KSEM technique. To evaluate this technique we applied case study research as suggested in Hevner et al. (2004). In the case study the KSEM technique is evaluated on the following four aspects: correctness, completeness, ease of use, and practical value for the organisation. Evaluation took place in the same company as mentioned before and is based on interviews with people involved in the project and on experiences of the researchers themselves in applying the technique. The case study set-up is presented in Section 3.2 and the results in section 5.

Conclusion: Based on the evaluation, Section 6 describes limitations and conclusions that have been formulated as well as directions for further research.

3.3 Evaluation case study set-up

To evaluate the KSEM technique, it has been applied at Unit4Agresso to model the knowledge sharing environment of 7 different business functions. To prepare for the case study a case study protocol has been established that mainly focused on the identification of the respondents (i.e. several people from the 7 business functions), definition of terminology and formulation of the questions in the interviews. It concerned open interviews and we decided to apply a storytelling approach in which respondents try to sketch a typical day behind their desk. The interviews could therefore be characterized as semi-structured. All interviews have been recorded and transcribed (i.e. into summaries) and KSEM has been used to analyse the interviews.

To address possible validity and reliability issues, typical for case studies, we used the methodological guidelines from Yin (2003). Internal validity concerns establishing causal relationships however, since this is not the main goal of the research, this is not considered as a main concern for the research. Construct validity is about "establishing correct operational measures for the concepts being used" (Yin, 2003). In line with these guidelines we used multiple sources of evidence, such as interviews, documents and direct observations. Furthermore, the interviewees checked our analysis and KSEM based on the interviews. External validity is about "establishing the domain to which a study's findings can be generalized" (Yin, 2003). To enable generalization, it is good practice to apply replication logic in multiple cases. In our case it depends on what is defined as the unit of analysis and hence the case. One could say that every business function to which KSEM is applied can be considered as a case study on its own. However, the context of the different cases is the same, so generalisation is limited. But the main goal is to design and evaluate KSEM and this was accomplished using this research design. Finally, reliability is about "demonstrating that the operations of a study ... can be repeated with the same results" (Yin, 2003). In line with these guidelines we developed a case study protocol to guide data collection and analysis. Furthermore, a case study database was established so that our research is traceable.

3. THE KNOWLEDGE SHARING ENVIRONMENT MODEL (KSEM)

This section starts with presenting the KSEM, which is based on the Knowledge Sharing Model of Bosua & Scheepers (2007). After presenting the KSEM, the motivation is provided for making changes to the original model.

The KSEM is presented in Figure 1 followed by a more detailed description of the different elements and relations between these elements.

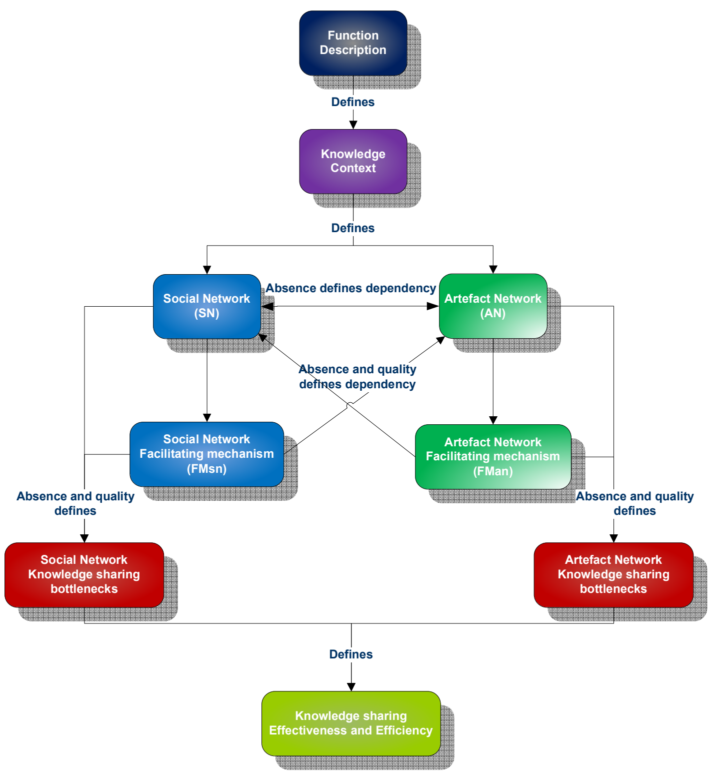

Figure 1: The Knowledge Sharing Environment Model (KSEM)

Function description
The Function element concerns the function of the respondent as described by his/her job description, location, department, resources, and culture. The function description defines the day-to-day activities of individuals, which are a good starting point for identifying needs to share knowledge based on knowledge contexts. As such,

focusing on the different functions in the organisation links the analysis to the right level of detail that is also understood by the organisation itself.

Knowledge context

The Knowledge Context element concerns the knowledge domains that are needed to conduct the activities related to a particular function. A knowledge domain can be defined as “a coherent cluster of insights, experiences, theories, and heuristics” (Schreiber et al., 2002). Knowledge sharing will typically take place within and across these knowledge contexts, hence focusing on the knowledge contexts brings us one step closer to identifying potential problems in knowledge sharing.

Social and Artefact network

The Social and Artefact Network elements concern the social and artefact networks that people leverage to share and acquire knowledge. In line with Bosua and Scheepers (2007), the social network refers to the network of social relations between people through which knowledge might be shared using some form of interaction, while the artefact network refers to a network of information and knowledge-based artefacts, in either analogue or digital form, which can be consulted directly. During this research it became apparent that the absence of the artefact network increased the dependence on the social network and vice versa, as indicated by the relations between the elements in Figure 1.

Facilitating mechanisms

The Facilitating Mechanisms elements are closely related to the previous elements and act as moderators within and between Social and Artefact Networks. Examples of mechanisms for Social Networks are knowledge brokering roles or incentive schemes while examples of mechanisms for artefact networks concern technologies to support the capturing, structuring, and disclosure of knowledge. Similar to the dependencies on the network level, the absence and poor quality of facilitating mechanisms increases the dependency on the artefact network and vice versa, see also Figure 1.

Knowledge sharing bottlenecks

The Knowledge Sharing Bottleneck elements for the Social and Artefact network concern barriers for the free flow of knowledge in the organisation (Mueller-Prothmann, 2004, Helms, 2007). Typically, the absence and/or quality of the networks and facilitating mechanisms are an indicator for potential knowledge sharing bottlenecks. Examples of knowledge sharing bottlenecks in the social network might be people with no or only few sharing relations (Helms, 2007) or a culture that does not foster knowledge sharing (Janz & Prasarnphanich, 2003).

Knowledge sharing efficiency and effectiveness

The final element concerns Knowledge Sharing efficiency and effectiveness. Where knowledge sharing efficiency refers to the amount of time, effort, and expenses needed to share knowledge, knowledge sharing effectiveness refers to the usefulness of knowledge that is shared (Bosua and Scheepers, 2007). Both efficiency and effectiveness of knowledge sharing are directly influenced by the knowledge sharing bottlenecks that are found.

Impact of bottlenecks

Not every bottleneck that is found will have the same impact on knowledge sharing efficiency and effectiveness. To get more insight in this impact a Bottleneck Impact measure has been developed. This measure is not an exact calculation of the impact of the bottleneck in financial terms, but concerns a percentage measure of knowledge sharing that it hinders for a particular business function. The reasoning behind this is: if a function is largely dependent on a specific knowledge context and the sharing of knowledge in this knowledge context is heavily dependent on for instance the social network, then a bottleneck related to the social network has a large impact on knowledge sharing efficiency and effectiveness in that function. Consequently, the Bottleneck Impact (BI) for a bottleneck X is calculated as follows:

$$BI_X = RI_{SN/AN} * KC_Y$$

where RI is the relative importance, as a percentage, of respectively the Social and Artefact Network and KC is the relative importance, as a percentage, of the Knowledge Context Y. As bottlenecks might influence the efficiency or effectiveness of knowledge sharing (or both), each bottleneck is classified as an effectiveness or efficiency bottleneck. When it concerns the time, effort or expense it takes to gather knowledge, it is an Efficiency Bottleneck (EfyB). When it concerns the quality of the knowledge, i.e. usefulness, it is an Effectiveness Bottleneck (EfsB). Finally, calculation of the bottleneck impact gives good insight into the magnitude of the identified knowledge sharing bottlenecks. Such insight is key to prioritizing knowledge sharing bottlenecks.

KSEM Graph

A KSEM graph is an instantiation of the generic KSEM presented in Figure 1. Such an instantiation is typically created for each function that is being analysed. Besides the relation between the elements, the KSEM graph also provides insight in the Bottleneck Impact. An example of a KSEM graph is shown in Figure 2. How such a KSEM graph is created, is explained in section 5.

In the remainder of this section the differences between the KSM model and the KSEM technique are discussed. First of all, a new element was introduced in KSEM that was left implicit in KSM: knowledge sharing bottlenecks. Introduction of the bottleneck element is explained by the goal of KSEM itself, namely the identification of bottlenecks. Secondly, it was decided to replace Shared Work Context by Function Description and Knowledge Context based on the experiences in the interviews. According to Bosua and Scheeper (2007) the shared work context is the common ground between people that is required to be able to share knowledge. Although it is an important condition for knowledge sharing between two persons, it did not provide enough orientation in our analysis. What was needed in the analysis is a good overview of the knowledge that is required by an organisation. Therefore, it was decided to introduce the elements: Function Description and Knowledge Context. The reasoning behind this is that the function description is a good indicator of the knowledge that is required to perform particular tasks. All functions in the organisation hence provide a good overview of all tasks and hence knowledge that is required.
Thirdly, the bottleneck impact calculation was introduced. After finding several bottlenecks the next logical question was which bottleneck needed to be addressed first. To determine the relative importance of bottlenecks we introduced the bottleneck impact. Finally, the KSM is a model and the KSEM is a technique. The goal of the KSM is to provide insight in those elements that are relevant for knowledge sharing efficiency and effectiveness. KSEM is a more pragmatic application of KSM in which the knowledge sharing environment is modelled, i.e. in a KSEM graph, and bottlenecks and their impacts are determined.

5. CASE STUDY RESULTS

In this section, the results of applying KSEM to one of the functions at the case study company are presented. At the support department we interviewed 3 software support consultants, 2 technical support consultants and the departmental manager. Besides interview data, we also collected data from direct observations of support consultants and by studying the content and statistics of the knowledge base, customer support application and telephone conversations records containing issues, status, and solutions.

Support consultant function

Robert is a support consultant who works in the Customer Support department. The main goal of a support consultant is to support Unit4Agresso Wholesale customers. Support consultants make use of a customer support application to record customer problems. Many support consultants also use this application as a knowledge base. Since it contains solutions to all solved calls and links to individuals involved in a specific call, certain calls can be solved by following a defined routine, which are real time-savers. Some of these routines are easy enough that they can even be performed by the customers themselves. By supplying customers with this type of knowledge, support consultants can shorten the time needed to solve a given problem and decrease the amount of customer calls.

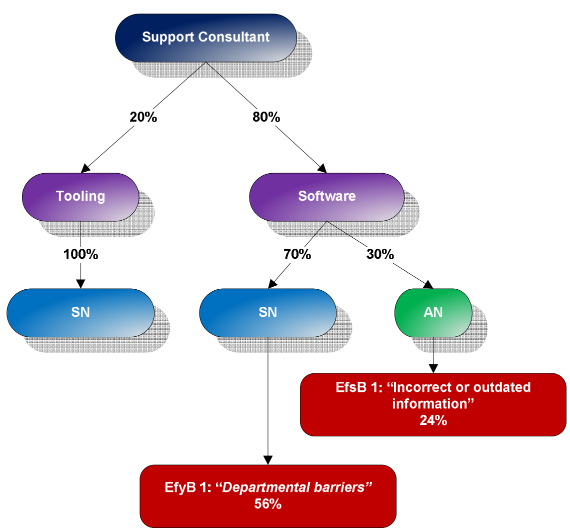

Figure 2: Knowledge sharing environment of a support consultant

Knowledge context

A support consultant uses knowledge from two knowledge contexts: Tooling and Software (cf. Figure 2). The Tooling knowledge context concerns knowledge about tools, which a support consultant uses in his work. Examples of these tools are the Customer Support application, Knowledge Base and PBX software. This knowledge is strongly tacit and is shared through the social networks by means of guided observations. The Software knowledge context concerns knowledge about Unit4Agresso Wholesale software, such as process flows, module parameters, bug tracing, and trouble shooting. Customers require this knowledge to solve their problems. This knowledge is partly codified and can be found in training documents, the customer support application and knowledge base while the tacit part which is difficult to codify, is shared through the social network.

Social Network (SN)

The SN of the support consultant consists of fellow Support Consultants, R&D- and Customization colleagues. If it concerns knowledge about Tooling, the support consultant relies mostly on his SN. For knowledge concerning the Software he relies 70% on his SN. The most used method for knowledge sharing within the Customer Support department is face-to-face communication while for inter-departmental knowledge sharing it is the phone (60%), followed by e-mail (40%). The main reason for this difference between intra- and inter-departmental knowledge sharing is the physical distance between the departments. However, support consultants prefer face-to-face communication as it enables highly dynamic interactions and enables instant knowledge sharing. They consider it to be efficient and effective as it provides a direct response as confirmed by the support consultant:

"I have a strong preference for personal contact. Even when I've sent an e-mail, I go personally to that person… Sometimes it is hard to describe a problem in an e-mail. Sometimes I find e-mail to be very impersonal. "

In the case where face-to-face communication is impossible, support consultants prefer the phone to e-mail as it supports direct communication and feedback. Even in critical situations, the phone has preference. The support consultant can better describe specific customer needs verbally than in writing. He can elaborate on unclear concepts and supply extra information using the same phone call. Only when the required person isn't available by phone, the support consultant will use e-mail to share knowledge. Support consultants claim that the e-mail response rate is lower than that of phone calls. Furthermore, sometimes more than one e-mail is required to describe the needed knowledge which makes email less efficient than the phone. The upside of using email is that it is easier to transfer codified knowledge and hence codified knowledge can be re-used.

One bottleneck often mentioned, is departmental barriers encountered when colleagues from other departments need to be approached. Two reasons mentioned are the lack of interest in each others' problems and lack of understanding each other's interests. These barriers are even worse if it concerns knowledge sharing with other product lines in the company. This kind of collaboration is problematic since employees often don't know who has the right knowledge and sometimes employees don't get any responses to their questions. This causes irritation and impacts on the flow of knowledge in the social network which in the end influences the effectiveness and efficiency of knowledge sharing in the organization.

Artefact Network (AN)

Support consultants rely on an artefact network only for the Software knowledge context (cf. Figure 2). However, the artefact network is not rated as important as the SN. The AN consists of a Knowledge Base, which is centrally accessible through the Internet, and contains key codified knowledge such as standard operating procedures, solutions to frequently occurring errors and problems and elaborate help files. The AN is important for support consultants because all interviewed support consultants confirmed that they first consult the AN before using their social network. Codified knowledge captured in the Knowledge Base increases the efficiency and effectiveness of their work, which in turn increases customer satisfaction.

"*… when I go to a customer I first read the reports in the knowledge base (of all the other support consultants that go there), we see [know] the problems and all the information related to that customer…"*

The AN can be regarded as mature, but there are still some improvements to be made. The following sub sections elaborate on potential improvements.

The Knowledge base

Support consultants are required to produce at least 2 codified knowledge documents monthly for the knowledge database. Due to time constraints, many support consultants cannot produce these documents for the knowledge database. The presence of key codified knowledge decreases the workload of consultants since codified knowledge from the knowledge base enables many customers to solve problems themselves. Without codified knowledge customers need to call the helpdesk - these calls take longer since there are a limited number of standard solutions documented in the knowledge base which has a negative influence on the efficiency of knowledge sharing

Customer support application

The core software used by support consultants is the customer support application. This application contains all information about customer calls, such as customer details, problem details, and chosen solutions, which makes it a valuable source of knowledge. However, the current version of this application still needs improvement. Based on interviews with support consultants and direct observations, we identified out-dated, inconsistent or erroneous information captured which makes the work of the support consultant almost impossible. If support consultants do not check the accuracy of information, he may diagnose problems incorrectly. Correct information is therefore key to effective knowledge sharing.

Bottlenecks

Application of KSEM for the support consultant function, as described above, resulted in identifying 2 major bottlenecks (EfyB 1 and EfsB 1) with respect to knowledge sharing. :

EfyB 1. Departmental barriers (in the social network)
EfsB 1. Incorrect and outdated information (in the artefact network)

The bottlenecks followed directly from the interviews with the various people in the Customer Support department. The first bottleneck, follows from the fact that knowledge on software does not freely flow between departments. This is an important barrier as a support consultant for instance depends on software knowledge from R&D (i.e. details on how the software works) or Consultancy (i.e. customisation of the software) to solve a customer problem. A lack of interest in each others' problems and lack of understanding each other's interests are causing these barriers. The second bottleneck concerns incorrect and outdated information in the information systems that the support consultants use in their work. Consequently, support consultants might diagnose problems incorrectly and propose the wrong solutions to customers. Both bottlenecks are not new in the sense that they are unknown in KM literature. However, they matter for the organization and are important here to demonstrate the application of KSEM

Next, KSEM was used to put these bottlenecks into the right knowledge context of the support consultant function. Once KSEM was created, the bottlenecks' impacts were calculated respectively as 56% for EfyB1 and 24% for EfsB 1 (cf. Figure 2). We will briefly explain the calculation of the bottleneck impact of EfyB1. During the interviews the support consultants were asked to indicate to what extent they are dependent of different knowledge contexts and networks relevant for their function. This is expressed as a percentage in Figure 2 illustrating the (relative) dependency. In Figure 2 it is shown that a support consultant depends 80% on the Software knowledge context and only 20% on the Tooling context. Then for the Software knowledge context, a support consultant depends 70% on his social network compared to the artefact network. This results in a total bottleneck impact of 0,8 x 0,7 = 0,56 for the Departmental barrier bottleneck that affects the social network in the Software knowledge context.

From the bottleneck impact calculation, one might conclude that EfyB 1 is more critical than EfsB 1, i.e. 56% versus 24%. However, from the interviews it was learned that a support consultant will first consult the artefact network and if he does not find any answers there, he will consult his social network. Due to the immaturity of the artefact network he strongly depends on his social network, i.e. 70% versus 30%.

6. EVALUATION OF KSEM

The application of KSEM has been evaluated using the criteria of correctness, completeness, ease of use, and practical value for the organisation. This evaluation is based on a discussion with the Knowledge Manager at Unit4Agresso and experiences of the researchers as the KSEM graphs were created.

Correctness: to ensure correctness of KSEM, findings were later validated with those involved. Furthermore, the KSEM graphs were discussed with managers. They found that KSEM gave valuable insight into the knowledge sharing environment. Some managers were surprised by the dependency on some knowledge contexts and the impact of bottlenecks. Validating the accuracy of the impact formula requires the validation of the calculated bottleneck impacts. The validation of a single bottleneck impact is hard to validate as it involves fuzzy concepts such as knowledge. However, the intention was to provide a relative impact measure and not an absolute impact measure. The relative impact is easier to validate as it is possible to check if respondents agree with the relative bottleneck impacts.

Completeness: indicates whether important elements are missing in KSEM, resulting in bottlenecks that were overlooked in the analysis. This situation was not encountered with the 7 functions that have been analysed in total. KSEM could even be called over-complete because we did not really make full use of the Facilitating Mechanism elements of KSEM during the analysis phase. Although Facilitating Mechanisms were discussed during interviews we did not see any added value in explicitly modelling them.

Ease of use: an important aspect of a modelling technique is that modelling is easy to use and that stakeholders in the project can easily read and interpret the models, i.e. KSEM graphs. In this instance the researchers are the modellers, so it is difficult to come to an objective evaluation in this regard. However, the number of different elements in KSEM is modest and therefore not difficult to master. Understanding of the elements might require some knowledge of the KM domain though. The relation between the elements might be less straightforward as demonstrated by the support consultant example in section 5. Here the impact of the SN bottleneck was higher than that of the AN and seemed therefore more important. However, the interviews showed that the SN is important because the AN is under-developed. For the readability of the KSEM graphs we had more objective measures because we communicated our findings, including KSEM graphs, to the respondents to check our interpretations. This revealed that respondents find the graphs most readable and gives a simple but good overview of the role of knowledge sharing in their activities.

Practical value for the organisation: in the end, KSEM should have added value for the organisation. The value for the case study company can best be demonstrated by showing the end result (table 1). The columns in table 1 represent the particular functions in the company that have been analysed using KSEM (eight in total). The rows in table 1 represent the bottlenecks that have been found. As the functions were analysed separately, it was required to harmonize the naming of the bottlenecks because it turned out that similar bottlenecks were named differently for the various functions. For example, the bottleneck of 'incorrect and outdated information', as found for the support consultant function in section 5, is renamed to 'quality of codified knowledge'. Finally, the cells in table 1 indicate the impact of a bottleneck for each function. For example, the impact of the departmental barriers bottleneck is 56% for a support consultant and 66% for an information analyst. According the KM project manager the table provided useful input for prioritizing initiatives to tackle the knowledge sharing bottlenecks. In terms of average impact the 'availability of persons' (58,8%) when needed for knowledge sharing is a priority 1 bottleneck.

Table 1 – Prioritisation of knowledge sharing bottlenecks

Bottleneck	Support Consultant	Software developer (R&D)	Software developer (Cust.)	Information analyst (R&D)	Information analyst (Cust.)	Project manager	Software Consultant	Technical Consultant	**AVG**
1. Availability of persons		64%	48%	66%	57%				58.8%
2. Departmental barriers	56%	62%	51%						56.3%
3. Accessibility of codified knowledge				24%	39%	36%	54%	76%	45.8%
4. Response time of requests							40%		40.0%
5. Missing knowledge context						65%	10%		37.5%
6. Quality of codified knowledge	24%	22%	4%	15%	24%				17.8%
7. Amount of codified knowledge		14%	12%				10%		12.0%

7. CONCLUSION

Current methods for knowledge auditing are limited when it comes to systematic analysis of knowledge sharing bottlenecks. This research fills this gap by presenting the KSEM technique. Using a case study it was demonstrated how KSEM can be used in a real world setting at a product software company to (1) identify knowledge sharing bottlenecks, (2) determine the impact of bottlenecks, and (3) to prioritize KM initiatives to solve these bottlenecks. Furthermore, the case study was used to evaluate KSEM using the following criteria: correctness, completeness, ease of use, and added value for the organisation. The evaluation showed that KSEM is rather over-complete than incomplete. Initially, Facilitating Mechanisms were defined as part of KSEM (figure 1). In the actual application of KSEM the facilitating mechanisms have not been used in creating the KSEM graphs (figure 2). Based on this finding one might come to the conclusion that Facilitating Mechanisms can be removed from KSEM. However, this is not what we recommend because they served as a useful guideline for conducting the interviews. Next, the evaluation revealed that 'hidden' dependencies between elements, e.g. social and artefact networks are currently not adequately addressed in the KSEM graphs. It might be a suggestion to extend KSEM in this respect. However, this might make the KSEM graphs more complex and perhaps more difficult to model and read. It should not be neglected to state that applying KSEM was rather time consuming. Therefore, it is recommended to start with some exploratory interviews to identify areas that require most attention. Thereafter KSEM could be applied to these selected areas instead of the whole organization. Additionally it is recommended to not apply KSEM in isolation but use it in combination with one of the knowledge audit methods presented in Section 2.

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