IT support in a Knowledge Management Process

A Field Study of a Quality Support Group in a Pharmaceutical Company

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Abstract

This study addresses the issue of knowledge management. The results are based on field study of a quality support group in a pharmaceutical company. Particularly, the knowledge work activities are analysed in a framework of a knowledge management process and its possibilities for IT-support. From the results I can conclude that mainly explicit knowledge is managed in this process. However, the specific use of two knowledge-mediating systems seems to be extremely important ("the very lifeline") throughout this knowledge management process. Knowledge can be transferable and distributed electronically among dispersed co-workers, adaptable and tailor-made to the needs of different users, and applicable directly to practitioners. In a discussion of a more general IT-based knowledge management process I go beyond the specific use of these knowledge-mediating systems and try to identify some further needs and requirements.

Keywords: knowledge management, knowledge management process, IT-support, field study, requirements

BRT Keywords: EG, GC, HA

Introduction

It is widely acknowledged that knowledge is one of the most important assets of organisations. Efforts are intended to retain, analyse and organise employees' expertise, making it easily available anywhere, any time. This is because of the difficulties in finding effective solutions to problems like; information and knowledge are hidden in the companies document repositories and people's minds, experts and key persons act in a interdependent way as consultants, groups of expertise are often virtually organised, and some experts leave the company with a lot of experience. All these problems refer to the

complexity of articulation and communication between knowledge workers that are distributed in "time and space". To meet these problems the concept of knowledge management is considered as the key strategic process in much knowledge intensive companies of today (Spender, 1996). Knowledge management aims at identifying the corporate knowledge in collective memories and facilitating communication and co-ordination between people who actually create it and people who really need it (Wathne, Roos & von Krogh, 1996).

Although knowledge management could be seen as an issue in human resource management, or organisational theory, beyond any specific technology questions, there are important aspects of work that can be supported by information technology. In this sense previous work on knowledge based systems should not be disregarded. The aim was to concede a computer what an expert knew in order to support the process of problem solving and decision making in a narrow knowledge domain. But deliberately these approaches became overestimated and concentrated primarily on validating the true knowledge of the rule-based expertise (Firebaugh, 1989). It has been identified that they had no support for collaborative workspace where knowledge could be co-ordinated and distributed among co-workers (Snis & Johansson, 1997; Snis, 1997).

Consequently, research in the field of CSCW seems to provide solutions for important parts of the overall knowledge management problem; communication, co-ordination and distribution of knowledge between interdependent individuals and groups that are geographical dispersed (Schmidt & Bannon, 1992; Bannon, 1998). For instance, groupware support for managing knowledge and expertise has been a growing interest. The origin of this advancing effort comes from the field of organisational memory, which has been widely developed during the last decade (Conklin & Begeman, 1988; Ackerman & Malone, 1990; Ackerman, 1994; Kutti & Virkunen, 1994; Kristoffersen, 1996; Conklin, 1996; McDonald & Ackerman, 1998).

In recent years e-mail, groupware packages, hypertext systems, and Intranets or Extranets are on the list of technologies that have been further developed for this purpose (Andreu & Ciborra, 1998). More specifically there are now efforts on groupware support for the concept of knowledge management (Orlikowski, 1992; Alavi, 1997; Conklin, 1998; Robertson, Sørensen & Swan, 1998). Work on both document management systems and digital libraries has initiated efforts towards aspects of knowledge management as well. New web-based application tools provide support for workgroups via collaborative workspace (Huber, 1998; Kirn, 1997). In sum these efforts have turned out to be categorised mainly into two different streams of support: namely *the creative learning approach* and *the capturing and reuse approach*. In respect to knowledge management, I believe that these approaches are two sides of the same coin and both of them should be included in a IT-supported knowledge management.

Only some of the previous work tries to understand what knowledge management really is and what main activities are included (Spender, 1998; Alavi, 1997; Van Heijst et al, 1998). Therefore, it would be of great importance to investigate field studies aiming at analysing the actual knowledge work, in order to find requirements for IT-support. By using the results from several specific field studies in both analysis and design of knowledge management would be very fruitful when informing the general design of such systems. This also means that a specific field study may both gain from and contribute to the development of general applications for knowledge management.

The purpose of this paper is to report from a field study, aiming at analysing work activities in the knowledge management process of a quality support group. One intention is to inform the design of IT-based knowledge management. Based on a literature review I outline a framework of knowledge management, which I attempt to apply on the field data. The computer support and co-operative work issues from the field of CSCW are of special interest when investigating the links and gaps between people who are supposed to create and provide knowledge, and people who are supposed to use and apply knowledge.

In the next section my research approach is introduced. In the following section a review of the main concepts related to knowledge management is outlined in order to form a good basis for the analysis of the results. Next section describes the company and the work setting studied. Then I analyse the work activities in the knowledge management process of the quality support group. In this analysis the issue of groupware applications comes front as a tool for managing knowledge. From this analysis a discussion about further requirements for IT-based knowledge management is followed and finally I end up with concluding remarks and future work initiatives.

Research Approach

Field studies address topics related to understanding and supporting communication among interdependent actors in their work process (Carstensen & Sørensen, 1996). Based on a field study of a quality support group this work focussed on the daily work of managing knowledge. This group is specialised in validation concerning processes as well as technical equipment when producing pharmaceutical health care products. Having such a group as an "organisational laboratory" for examining the concept of knowledge has been very favourable as it is recognised as a specialist group with expertise in validation, aiming at support other parts of the organisation. Further in this paper I will refer to this group as just *Validation.*

The study took place over a period of four months and approximately fifteen semi-structured interviews, five meeting participate, and several direct observations and social networks were carried out. In order to clarify themes and conceptions the material has been discussed with the employees in several informal meetings and thus ascertain reliability. In order to obtain a coherent understanding of the specific knowledge work in this group, the research approach was inspired by ethnographical methods (Hughes et al, 1993). By "walking and talking" through the organisational processes, in which the study takes places, I have gained a rich picture of the work and the different conceptions of the involved actors. In order to obtain a holistic view of the knowledge process interviews with some partners, seen as *clients* or *users* of the support group, were performed. Moreover an analysis of on-line archives and two knowledge-mediating systems was done. This approach has been extremely important when investigating settings where knowledge and knowledge management have a tight coupling to both collaborative work and computer support.

The results were analysed in a knowledge management framework, inspired by Nonaka (1995), Alavi (1997), and Spender (1998). What is important to say, is that I am addressing the issue of co-operation when investigating the activities in a knowledge management process. This also encourages me not to regard the notion of knowledge

management as an independent entity, a product, delivered throughout a stepwise process. Instead, my perception of knowledge management is that it needs cognitive efforts in an individual as well as social process, in which it is further integrated and explored by people as knowledge workers. Knowledge, in this notion, requires for efficiently perform particular work activities.

In respect to computer support, the field of CSCW has contributed greatly to this work. In processes of managing knowledge, groupware is understood as a technology supporting dispersed people in collaboration through co-ordination, co-operation and communication (Schmidt & Bannon, 1992; Schmidt & Simone, 1996; De Michelis, 1997). Partly, in this paper I describe more specifically such a groupware use as two knowledge-mediated, web-based applications for quality support. These systems are in the following referred to as the *R-system* and the *P-system*.

The result from this field study has given a rich picture of the actual state of capabilities and limitations. This also means that it offers a very low degree of generality. As such, the conclusions derived from this work are not an extensive list of needs and requirements that can be used in any co-operative organisational setting where knowledge management processes are identified. One could say that if knowledge management incorporates the activities analysed in this actual collaborative field setting, then these requirements might be valid. In order to increase the generality it is necessary with further investigation and empirical evidence of the suggested requirements and technologies.

A Theoretical Framework

It would have been useful to have a theoretical framework that could enable distinguishing certain aspects of work worth investigating in work practice of the quality support group *Validation*. As such, a framework of knowledge management is not yet thoroughly elaborated due to its new advancements. However, by reviewing the literature in this and related topics it is possible to summarise some main concepts that seem to be important.

Notions About Knowledge

Not surprisingly, there is a discussion about the definition of knowledge and how it relates to or rather differ from information. In this sense knowledge can be regarded as closely related to information but are not of the same meaning. In order to become knowledge some information needs to be interpreted and applied in a specific situation by a human (Sandberg, 1994). True knowledge belongs to people, and are the organisation's assets only through their application, capture and re-use (Conklin, 1998). According to Nonaka (1995) knowledge is preceded by information and in that process interpretation, reflection, and action take place. Especially, experiences and lessons learned acquired during daily work activities can be incorporate. An important notion is that expertise and how to do-knowledge could be defined as procedural knowledge used in problem solving and decision making (Firebaugh, 1989; Nonaka, 1995).

Generally, knowledge is in some way classified into two various forms. The first one comprises of individual talents and knowledge that is acquired through education,

training, experience, and cognition. This is what Conklin (1998) name informal knowledge. It includes ideas, assumptions, meanings, stories and points of views and all of it is "wild" and ephemeral. Nonaka (1995) agree while saying that it is tacit knowledge that underlies these assumptions. Those soft aspects, as proposed by Ramage & Reiff, will further deepen the understandings of a specific knowledge theme. Buckingham-Shum (1996) would name it process-oriented knowledge as it will be articulated and negotiated through the process of gaining understandings.

The second form of knowledge considers knowledge repositories that are available in such forms as documented research papers, reports, books, specifications, and software. In such repositories the knowledge is more explicitly explained as it has the format of for instance a report or it is expressed in minutes from meetings. This is what Conklin (1998) names the outcome of knowledge work; formal knowledge as documents that expose the decisions made in specific work situations. It could also be named explicit (Nonaka, 1995) in the sense of rules and specifications in how to perform work procedures. According to Ramage & Reiff (1996) those hard aspects will be easier to capture just because of its explicit nature. Buckingham-Shum (1996) argues that this product-oriented knowledge will be the result of the knowledge creating process and this result is possible to explicitly represent in a common knowledge base.

Knowledge Management Processes

A knowledge worker is an expert or a specialist in a certain work domain. In complex work domains the operations of work are often such that individuals alone cannot handle a certain task (Wathne et al, 1996). Even though each individual might have her or his own area of expertise and responsibility it is mainly through a joint co-ordinated effort they could create knowledge and perform their work (Kirn, 1997). To become a knowledge worker they cannot therefor just be a highly specialised, skilled worker in a particular subject. She or he must also be able to collaborate with other knowledge workers (Drucker, 1994). This activity is in accordance with the knowledge work characterised by Buckingham Shum (1996). He characterises knowledge work as interdisciplinary and recognised as a collaborative process aiming at a common goal; to learn about the problem and its alternative solutions.

Nonaka (1995) illustrates another relevant view of this process. He claims that the knowledge creation starts at the individual level, moving up to the collective group level and finally reaches the organisational level. He also describes the knowledge creating process as different patterns of interaction between tacit and explicit knowledge, and through social interaction between individuals.

According to Mentzas & Apostolou (1998) the flow of knowledge between people in a knowledge work setting can be defined in a knowledge management process, which starts with (i) a generating phase, which aims at identifying the desired content of knowledge by creating ideas and discusses contributions among involved actors. It follows by the next phase (ii) organising the knowledge, which aims at finding a suitable scheme in which to represent the knowledge generated. In order to increase and refine its value the third phase is (iii) developing. The fourth phase (iv) distribution refers to how people gain access to the knowledge in order to use it. They apply this framework of knowledge management when doing a comparative analysis in consultancy firms.

Alavi (1997) outline another framework of a knowledge management process that seems to be very useful. It consists of four different phases embedded in an organisational setting with a technological infrastructure included. These phases are; i) Creating: an important activity seems to be creation of new knowledge. By continuously acquiring new knowledge in problem-solving, decision-making, and training, knowledge creation takes place. (ii) Organising: Knowledge created need in some sense to be synthesised and refined in order to reach a certain level of formalisation. This activity aims at putting the knowledge in such a form that it is accessible to others. (iii) Distributing: This activity concerns the way in which the knowledge is communicated among people. (iv) Applying: This activity refers to how and when the knowledge is applied and also to what degree it is embedded in daily work practise. In relation to the previous activities this one is more directed to the individual "receiver" or user of the knowledge.

Strongly inspired by all of the above authors I will finally use the framework outlined by Alavi (1997). This one seems to incorporate much of the others point of views and it will be useful in the analysis of my field study. One point is that a knowledge management process usually takes place through interaction between people in a collaborative setting (Nonaka, 1995). Another point is the possibility to identify certain work activities (Buckingham-Shum, 1996). A further important aspect is that of not being so systematic in the definition like Mentzas & Apostolou (1998). These work activities may occur in a certain order and may overlap, but this is not always the case.

The empirical study

The field study was carried out in a quality support group in a large Danish pharmaceutical company. The quality support organisation in this company is organised into seven different groups. Each of them has their own expertise area and their main purpose is to support the product supply, development departments, and other sites within the organisation. As a worldwide company these sites are geographically dispersed. Many regulatory authorities expect pharmaceutical manufacturers to comply with "good manufacturing practice", GMP. In order to deal with this highly regulated and complex industry it is extremely important to provide employees with the necessary knowledge of current GMP.

The quality support group in the current study has special competencies within validation. Seven employees and one manager are included in the group and most of them are chemistry engineers. Generally, validation work can be described as a planned and systematic way to assure collection of quality records, which demonstrates that the entity that is subjected to validation is in compliance with the current GMP requirements. The different entities subjected to validation may include process equipment, computer systems, buildings and utility systems. All these entities have impact on the product quality, identification and documentation as well as process reproducibility.

As knowledge workers the employees in this quality support group are typically concerned with developing ideas, interpreting standards, solving problems, and exchanging knowledge. As a support department they depend heavily on the expertise of their employees and engage in value-added activities for their clients. Mainly, they put considerable emphasis on applied creativity for solving problems of their internal departments.

"As a quality support unit our role is to see the different organisational sites as our main clients. But I also act as the extended arm from the regulators and protect the end-client of our products - the patient."

They regard themselves having at least three different roles. Firstly, they are validation experts. They must know all the GMP requirements about validation work. They need to be fully updated on the on-going modifications in their expert domain, and they in turn seek to change others through reformulating procedures and adjusting them to specific use within their organisation. Secondly, they need to assure quality in the use of GMP requirements. By reviewing and accepting operational documents they assure that validation work is performed in compliance with current regulations. Thirdly, they are supporters. Acting as internal consultants they help operational workers to plan the work of validation and to solve problems that occur out in the product supply sites. Two of the employees in this quality support group are actually acting like "flyers". Being a flyer means that you are temporarily located in a "client site" during a rather long period of time. This is typically to be involved as a consultant in a project taken place in a product supply unit. This is a very popular way of working; collaborate and being actively participating in the operational units where the problems really occur.

What is interesting in the supportive part of the validation activity is that it is not only an individual task. Efforts of turning information into knowledge involve individual as well as co-operative tasks. No one can do the job alone. No worker is all-knowing and all-powerful; workers act and interact on the basis of partial-knowledge; they do not know or have access to the whole picture. In the validation support unit they have, in some sense, their own area of expertise. This is not very clearly defined but they know each other's topics and collaborate due to this, which may imply that two of them can be involved in the same "project" and thus complement each other. Also this project collaboration with the product supply departments are crucial as they are the main users, those "receiving" or rather "using" the knowledge provided by the quality support knowledge worker. As one interviewee put it:

”The problem of having lack of knowledge is solved by the use of *procedures*. These are in fact the mechanisms assuring that we any time know how to do it.”

Knowledge that is distributed by the knowledge workers in quality support is not just supposed to be taken for granted. For operational knowledge workers applying knowledge needs efforts as well. For instance in product supply, applying knowledge is to do judgements in their daily work activities and to reformulate external requirements into their own internal work procedures and instructions. Practically this means that even highly structured knowledge, such that e.g. procedures written in formal documents, involves a high degree of creativity and experience.

From the above we can realise that co-operative knowledge work is highly complex. The many actors involved have different perspectives and backgrounds. In order to assure that the validation activities are done correctly, the validation has to be properly planned, co-ordinated and documented in a collaborative effort throughout the organisational process.

Identifying a Knowledge Management Process

In this analysis I characterise the key activities when managing knowledge in the quality support group Validation. The analysis is presented in accordance to the knowledge management process, mainly proposed by Alavi (1997) and described earlier in this paper.

Creating Knowledge

One key activity in the process of managing knowledge in Validation is to create new knowledge. External information bases facilitate acquisition by continuously identifying new knowledge in the environment. Employees search through or subscribe to these external information repositories, where modifications in the global regulatory affairs reflect changes to their expertise area. By participating in external conferences and courses the employees have opportunities to keep in pace with the extremely changing environment and new trends. This acquisition implies that information needs to be interpreted and developed, i.e. created, in order to be used in their work activities and thus contribute to better practices. Also internal initiatives based on analysis of failures, daily work experiences, creative ideas, or efforts from research and development are reasons that can start creating new knowledge. This is a significant activity that draw upon acquire expertise and experiences from lessons learned. Different kinds of meetings are very useful to the employees at Validation. Problems solving in ad-hoc meetings are a quite usual way of handling upcoming problems. These meetings are supposed to be very focussed and short. Another meeting form is Focus Groups, which intention is to discuss and create new knowledge by putting people together with different perspectives on certain areas of expertise.

Organising knowledge

Another key activity concerns the organisation of knowledge. When organising knowledge and make it accessible to co-worker the classification of knowledge into explicit and implicit becomes crucial. Implicit, tacit and ambiguous knowledge is especially hard to organise in order to communicate and distribute to co-workers. As stated earlier, this study has not yet thoroughly investigated these tacit assets. One analysis is that in the Validation group, experiences and lessons learned from remote or on-site problem solving are communicated through email or phone calls, but not commonly recorded.

Not surprisingly, explicit knowledge was more obvious to find. Much of this knowledge was organised in internal archives, as formal documents. There is a great possibility in depositing knowledge in a form of documents as for instance the internal use of guidelines and procedures for a good practice within the organisation. An internal statement is made saying that these documents must be organised in a way that is applicable directly into work practice. Accordingly, this knowledge must be explicitly formulated in mainly two kinds of operational documents: *Requirements* and *Procedures*. In order to capture best practices and sharing it among co-workers this formal way of organising knowledge in Validation is extremely important. It does not only provide

organised knowledge that can be used directly by the workers but it enables an organisation that can be fully supported in their computerised tool as well. In the case of the quality support organisation this is provided through their intranet as a corporate knowledge sharing archive. When a large group of people, e.g. a specific support group, a development project or a focus group, needs to share a large number of documents this system is used to provide opportunities for distributing knowledge in an organised way. In short there are two different knowledge-mediating tools incorporated in that archive and both of them are extremely integrated in the actual work of managing knowledge in the group. These are accordingly referred to as the *R-system* and the *P-system*.

Organising explicit knowledge through current knowledge-mediating systems

a) The R-system

The R-system is a tool, which they have decided to use for specific common issues. The R-system shall ensure that work efforts are in compliance to current regulatory, external requirements and thus aiming at sharing better practices. The R-system contains functions that enable users or groups of users to design structures of documents to suit their own specific needs. Hence, it is the user or client, who owns these documents and who is empowered to maintain them in a valid state. The document format is therefore in editable word-files. Also standard operational procedures and templates are included in this format and accordingly facilitate the direct applicability to the users. A core characteristic of one such *Requirement* (included as a *document* in the R-system) is that it must add value to the company, and the responsible person in the relevant area must accept the added value. It must also be recognised by the "users"/"clients" as the accepted way of working and thus ensure constant improvements of the content and quality in their work processes. Another characteristic is that a *Requirement* may be divided into two sections. Section one discusses the specific demands and the rationale for a specific interpretation (if any). This section must be adhered to wherever the work described is carried out. Section two of a *Requirement* must be written in such a way, that it can be used directly by each site or unit. For specific needs this section can be written as a checklist. If relevant, references can be made to the *Requirement*, upon which the local implementation is based. When modifying a *Requirement* to meet local needs the result is another document, typically a *Procedure*, which are to be "looked upon as a template, “a better practice”". By using this system a certain level of harmonisation throughout quality support will be ensured and as such this system is conceived as a knowledge harmonisation and dissemination tool.

b) The P-system

The P-system is the quality system used for the electronic distribution of operational documents, followed from *Requirements* as *Procedures*. It aims at integrating the quality and business processes. In 1998 there were 6000 documents and they estimate that there will be about 15000 in 1999.The system is also intranet based and is therefor accessible from all sites in their world-wide organisation. The primary target group for the P-system is employees "using" operational documents. All documents are stored and indexed in a document management system, which controls versions and access as well. When a user wants to view a document, it is fetched from the document management system and presented in the P-system for non-editable use like viewing, navigating and printing. This non-editable file format is designed only for on-line publishing and is therefore the

default format shown in the browser. Some of the documents contain forms and templates that require access to word processors.

Accordingly, the P-system is the application system, which contains only index and applicability meta-information. The applicability system filters the documents so that only the relevant subset of documents is listed for a specific department. Each document has a "pre-page", which contains added information about the document. This matrix form is to facilitate co-ordination between actors to which the documents apply. All departments have their own list of applicable on-line documents. In that list the document titles link to more details about the documents. The documents in the P-system can be grouped into four levels:

- Top level - Documents applicable for all departments in the organisation
- Cross functional level - High level documents applicable to many departments or processes
- Department level - Documents assigned to (a) specific department(s)
- Item specific level - Documents related to specific item numbers or analysis numbers

Another central characteristic of the P-system is that it contains only approved documents and the documents that are only accessible as long as they are still effective. In order to visualise the status of each document there are coloured icons. A red bullet indicates that the document is issued but still not effective. A bullet saying "new" indicates that the document is issued within the last 14 days while a green bullet state that the document is effective. A yellow one indicates that the document is still effective but the expiry date has been defined.

Distributing knowledge

A central activity in the knowledge management process is the distribution of knowledge among co-workers. It is said before that this distribution activity is facilitated the more formalised the knowledge is. This activity aims at making it easy for people to find what or who they are looking for, and encourage them to find the appropriate channel. But one key problem of knowledge distribution is to decide which co-workers would be interested in what particular knowledge. In other words, who can provide what knowledge, or who is going to talk to whom.

One popular way of distributing knowledge is by holding mini seminars. People from the operational units propose some of the seminars. Others are suggested from the specialist group, seminars that they coincide that the co-workers need. They strive at looking from the perspective of the users when proposing subject and target group on these mini seminars. The administration of these seminars is supported by a web-based application with a database. From this system the administrator can read submissions for interest in order to anticipate the scope and plan. Apart from the popularity and scope they can also read the actuality and priority on different seminars from this computer-based co-operative routine. Email lists are produced in order to group individuals into collaborative information receivers. Email lists are used for instance when to announce different seminars and the email messages are usually enclosed with a link to the intranet, where the mini seminar application more precisely describes it. This is called a “*reminder*”.

Distributing knowledge and expertise can also be performed in a "remote" problem solving, typically by phone-calls or emails. One client calls for a solution to a specific problem and the expert needs to understand the context of this problematic case. Discussions on the phone are continued. Sometimes a phone call may end in visiting the site where the problem occurred like an "on site" problem solving. Even some times a meeting is arranged.

Distributing explicit knowledge through current knowledge-mediating systems

As said before, much of the structured knowledge is distributed to the local employees through their intranet and internal archives. The problem of who is providing what and who needs what is partly solved in the P-system by a distribution service, which is based on a semi-automated profile mechanism, as described before. In a department profile, the units have defined their business areas, processes and functions that are mainly of their concern. This kind of "applicability matrix" is also used when defining a specific profile of a document. By using the same attributes and attribute values they can see to which unit the document is applied. When there is a match between the departmental profile and the document profile a distribution service is provided by the workers at a document control centre. They are responsible for the establishment of the necessary email lists and the execution of the distribution service.

This way of distribute knowledge corresponds to a kind of narrow casting. As each department has defined their profile, this narrow casting is on a departmental level. In each department there is a responsible person maintaining the departmental profile and to some extent also knowing a few individual interest, i. e. user profiles.

Applying knowledge

In the quality support group knowledge management efforts are in this aspect aiming at providing sufficient criteria for applying good manufacturing practices. In the applying activity I now look from the perspective of those "receiving" or rather "using" the knowledge provided by the quality support Validation. Operational workers, in for instance product supply, use knowledge that helps them to do judgements in their daily work activities and to reformulate Requirements into their own work procedures and instructions. In practice, even highly structured knowledge, such that Requirements and Procedures, involves a high degree of creativity and experience. But as knowledge distributed by "experts" is not just supposed to be taken for granted knowledge application needs efforts as well, which implies that knowledge is created in a new context. Obviously, this activity overlaps the creation activity. Practitioners here are creating new knowledge (when using *Requirements* and creating *Procedures*). This means that they in turn are interpreters, creators, as well as authors of the documents. All these documents play an extremely important role as formal and applicable knowledge about how to get the job done. This also implies a good reliance on their work procedures and instructions. In the quality support group this means that knowledge management is brought into the work procedures and thus assures that these are in compliance with external regulations as well as expertise in the work domain.

Discussion

Based on the findings presented above, several implications for design of IT-based knowledge management can be derived. Moving towards requirements means that the discussion here is only a first step. The suggestions are going to be discussed by point of departure from an organisational unit with a core competence and a knowledge management process that links and leverages the diverse repositories and facilitates the collaboration between people in the organisational context by use of technology.

In the quality support group Validation efforts of turning information into knowledge involves individual as well as co-operative tasks. The day-to-day work of the specialist group requires people who are able to extract knowledge from themselves as specialists, or from other knowledge sources, output it in a structured form, distribute, and maintain it over time. This process needs collaboration with the product supply departments, as they are the main users of this procedural knowledge.

First, in the knowledge creation activity, it is very important to come to an understanding of the background knowledge and assumptions about the actual context where the knowledge was produced. This implies that support would emphasise the means by which knowledge is created in the past to bear on present activities. In order to create knowledge, an acquisition process is needed as well. Technologies should support environmental scanning and information acquisition. The specific requirement of putting crucial external information and knowledge on-line is obvious. Subscriptions to on-line databases should be possible and such systems should also own some intelligence. Intelligent retrieval and navigation could support searching in the amount of various knowledge bases. Incoming news and changes to those knowledge bases should be indicated and "pushed" to the knowledge workers, too. Even if such "reminders" may train a passive information seeker it is an effective way of disseminating knowledge to groups of individuals that are geographically dispersed. There is a problematic tension between the intelligent use of information pushed and filtered in this way and the desire of getting them more active and creative in their knowledge work. However, this seems not to be a problem when being a knowledge worker.

In order to support the creation process functionality is further needed for establishing knowledge networks like discussion forum and email lists that put experts together. In such systems interdependent actors can exchange opinions as well as receive advice and comments. Experiences from and feedback on working methods or outcomes from specific problem-solving scenarios should also be supported effectively. Reviewing facilities, in which to comment on each other's documents, should support the authoring process in this creative activity. In respect to this, the developing process of writing *Procedures* is collaborative and the negotiation takes place as a reviewing process among co-workers of operators, quality people as well as specialists.

Knowledge needs to be codified. Implicit knowledge is not yet further investigated but some suggestions to organise this in a computer support exist. Sharing knowledge and solving problems in creative processes should be possible to record "on the fly". Discussions, brainstorming, and rationales on meetings should be recorded like the way in gIBIS or QuestMap (Conklin, 1988; Conklin, 1996). One problem of these systems is that it only aims at capture the rational aspect of the decision making and not the work itself. For ease of use, storing and retrieving knowledge technologies should be integrated in tools that "get the job done" (Kristoffersen, 1996).

Previous cases reported from phone-calls and email should be recorded and further organised in a "case repository". Much of the explicit knowledge organisation, expressing know-how by means of procedures, could be supported in document management systems. Huber (1998) has addressed this support when he discusses the integration of business processes and knowledge processes. He means that employees would be able to manage knowledge through document system in order to perform their work activities. A central requirement in such systems concerns the problem of dealing with the enormous amount of documents that are included in such a repository. Support for an extensive conceptual scheme for indexing and classifying knowledge should therefor be provided. Linking and structuring different problem cases, documents, knowledge references and experts in a way that corresponds to the users' specific demand is another important requirement. This support is valid for incoming emails as well.

From this field study one can learn that knowledge management technologies should only formalise knowledge, which is managed and acknowledged in a collaborative effort. By participatory knowledge management work, for instance co-authoring and peer-reviewing, knowledge formulated in documents can be said to be "committed". This facilitates that knowledge can be transferable and distributed electronically among dispersed co-workers (e.g. managed in the R-system and the P-system).

Furthermore, implicit knowledge transformation needs socialisation, which means interaction between people. As according to Van Heijst et al (1998), the distribution process of tacit knowledge is thus limited to identify the person who has the particular knowledge and encourage her or him to interact with the person in question. In Answer Garden experts are informed when a new question is added (by email) while users are not (Rodden, 1993). On the other hand, field studies show that some users asking questions to experts think of bothering them.

> "The one inhibition I felt using Answer Garden [was] knowing that the experts were typically busy and working on projects more important than my little…" (Ackerman 1994, p 251).

In this sense Answer Garden actually exacerbate it. Seen from organisational perspective experts are not obliged to maintain the organisational knowledge by using the systems. However, knowing which person is particularly interested in what areas, or rather needs to talk to an expert, would be truly recognised as an activity undertaken by a knowledge manager. This was also the conclusion found in Carstensen & Wulf (1996). Specifically it should enables actors to send messages to either a certain individual or to groups of individuals. One such advancing attempt is called knowledge mapping or charting (Jordan, et al, 1998; Glance et al, 1998).

When talking about applying knowledge the actual context should not be disregarded. It is inevitable to miss some aspects of the context by using and applying stored knowledge. IT-support for knowledge management should also be a more abstract tool reflecting a collection of social activities that are performed by skilled worker in the organisational culture.

A particular challenge of applying knowledge seems to be the degree of acceptance to the users. Reached to a certain degree of explicitly the knowledge should be accepted and then be recorded. What is sanctioned as reliable knowledge in this case depends on the interpretations and guidelines formulated in the *Requirements* and *Procedures*. The knowledge included should be adaptable and tailor-made to the needs of different users in

order to be applicable and usable to practitioners, support workers, and management. This is the case when they firstly create Requirements collaboratively and store them in editable file format in the R-system and secondly use them as *Procedures* of know-how in work practice in the P-system. One point is that they must trust the content of the knowledge managed in the systems. They have been actively participants in the beforehand process of negotiation and reformulation. Another point is that they must trust the tools at hand, the R-system and the P-system. The formality and accessibility in these systems are central aspects to their work performance. As stated by Schmidt (1997) these artefacts play an extremely important co-ordinate role as procedures in their daily knowledge work activities. Co-ordination functionality such as advanced searching, indexing, collaborative as well as co-ordination support (e.g. common document repositories, meta-information, applicability matrix, distribution lists, etc) is provided through these tools. They emerge as the standard mediated tools for the process of managing knowledge. These artefacts play the role of the true "lifeline" between the specialist group and the product supply people, too.

Further implications are that knowledge management is not only about management. It is about participation in different activities of knowledge management, quality assurance, and business performance. The result shows that these efforts seem to be tightly coupled and integrated into a common way of technology-supported "good practice". The issues of participation in the knowledge management process point at the importance of establishing a relationship between those, which are supposed to be specialists and those, which are supposed to be practitioners.

Last but not least, another important condition that was identified in this study was the motivation and expectations of what knowledge management really meant to them in their daily work activities. While one could expect that some hindrance of power could be found, that was not the case. In this study the people involved had a positive attitude towards knowledge management and it seemed that they understood the importance of sharing their knowledge to others without jeopardising their value as employed specialists. Thus the organisational culture in quality support group Validation seemed to fit well in a knowledge management perspective.

Concluding Remarks

The aim of this study was to analyse knowledge workers in a specific field setting with consequently implications for design of IT-based knowledge management. By analysing the knowledge management process from the perspectives of the CSCW field contributed to several findings. IT-support should be used as mechanisms that augments and interconnects people and resources so that knowledge can be created, organised, distributed and applied upon a computer supported collaborative workspace. One important argument is that these preliminary needs and requirements analysed in this study should be designed by combining tools and media. Due to its complexity one "over- all system" should not be considered. However, I hope that this initial study will provide a good basis for further work. A productive step forward would be to begin designing small applications providing a subset of the above functionality that facilitate a process with user interaction, step wise refinement, and effective management of knowledge. The over all study may end in providing considerations for facilitating a

working environment when designing and using collaborative knowledge management technologies.

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