Preserving the passion for knowledge Of engineers after the implementation of an ict-system: the role of communities in a Dutch case study

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In this paper the usefulness of the concept of communities (of purpose, interest and practice) for knowledge management and the role of communities in preserving the passion of engineers for knowledge, will be demonstrated in a case study made in two engineering departments of S Ltd, a Dutch knowledge-intensive company, which offers industrial services and total solutions. These departments loose knowledge because engineers leave the departments every five years. Last year, to counteract this trend, the knowledge landscape e-Knowledge (ICT system) was introduced, aimed at preventing this loss of knowledge, encouraging the reuse of knowledge and making work processes more efficient. The problem is that the engineers hardly use e-Knowledge. In this study a close look will be taken at the knowledge processes involved in e-Knowledge and at the role that communities of purpose, interest and practice may play in preserving the passion for knowledge of the engineers. The results show that communities of interest can indeed play an important role in improving the use of e-Knowledge, since membership of these communities makes engineers more interested in e-Knowledge and its possibilities. It is recommended that S Ltd. encourages and facilitates initiatives of engineers to start new communities of interest in the future by offering time, money, and means of communication. Further to enhance expertise sharing between engineers it is recommended to raise the level of awareness of the engineers of their preferred ways to share expertise (face-to-face, with collegues with a good reputation) and of the opportunities they have to do this (in projects, during talks with the mentor, in informal (social) talks in which stories are exchanged).

Keywords: *communities, ICT, knowledge management*

Nowedays we live in a "knowledge society", in which knowledge is the most important means of production and not capital, raw materials or labour (Drucker, 1993). Knowledge can provide a sustainable advantage (Dierkens et al. 2001; Easterby-Smith & Lyles, 2003). Growth of the service sector, automation, the development of new (information) technology, changing structures and work processes of companies and globalisation and, as a consequence, growing competition are a few causes for this development (Van Zolingen, 1995). This is why knowledge management has become very important for companies According to Davenport & Prusak (1998) knowledge adds value because:

> "Eventually competitors can almost always match the quality and price of a market leaders' current product or service. By the time that happens though, the knowledge rich, knowledge-managing company will have moved on to a new level of quality, creativity, or efficiency. The knowledge advantage is sustainable because it generates increasing returns and continuing advantages. Unlike material assets, which decrease as they are used, knowledge assets increase with use: ideas breed new ideas and shared knowledge stays with the giver while it enriches the

> receiver. The potential of new ideas arising from the stock of knowledge in any firm is practically limitless - particularly if the people in the firm are given opportunities to think, to learn, and to talk with another" (1998: 17).

Theory

Knowledge and knowledge management

Knowledge management in organizations is about knowledge. When one talks about knowledge, the question arises how it is to be defined. According to Davenport & Prusak (1998):

> Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the mind of those who know. In organizations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices and norms. (p 5).

Davenport & Prusak describe knowledge as a socially constructed reality, influenced by personal beliefs and values, forged in the rhythms of daily work, and visible in a company's products and services. Knowledge is complex because it is personalised. This makes it difficult to standardise and to share it effectively with others. Knowledge management in organizations is also about knowledge creation. Marsick & Watkins (1999) state 'Its focus is releasing creativity and invention in people, who in turn can use what they know to develop the capacity of people, improve practices and processes, and develop better products to serve the customer' (p 82). The process of knowledge management in organizations has been visualised by Weggeman (1997, 2000) by means of the so called knowledge value chain. The knowledge value chain comprises the following phases: determining knowledge in accordance with the strategy of the organization, listing the available knowledge in the organization, developing knowledge, sharing knowledge, applying knowledge and evaluating knowledge. The knowledge management process is continuous and cyclical in nature. The mission, the vision, the goals and the strategy of the organization are the driving forces of the knowledge value chain (Figure 1).

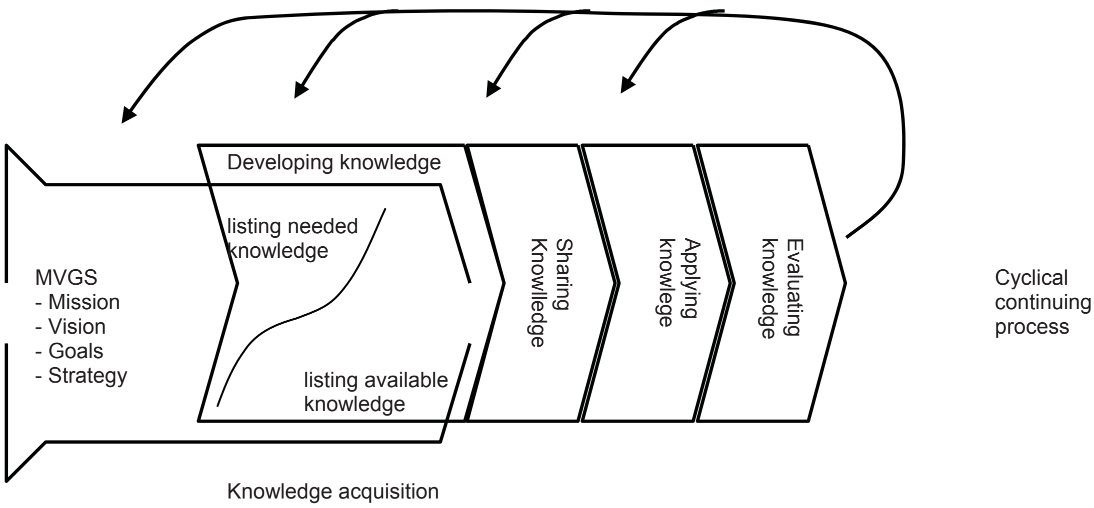


Figure 1. *The knowledge value chain (Weggeman, 2000)*

The term knowledge value chain has been chosen to emphasize that as knowledge moves further along the chain, its value increases from the perspective of the organization (Figure 1). Knowledge becomes really valuable for the organization if it is applied in the production process or in projects. But before application of knowledge is possible, it must first be known by employees and before knowledge can be shared, it must be developed and acquired. The arrows indicate that knowledge creation and knowledge exploration is an ongoing cyclical process.

Nonaka & Takeuchi (1995) describe organizational knowledge creation as a continuous and dynamic interaction between tacit and explicit knowledge. Tacit knowledge is personal, context-specific and therefore difficult to formalise and communicate. It consists of embodied expertise, a deep understanding of complex interdependent systems that enables dynamic responses tot context-specific problems. Explicit knowledge is transmittable in formal, systematic language. ICT systems are often used to codify explicit knowledge in information that is placed in shared repositories or organizational memories that offer the possibility of reusing information. In this view gathering, providing and filtering available explicit knowledge is central to knowledge management. A few decisions that have to be made in creating an ICT system to support knowledge management are: (1) what is the vision that guides choices about what to include or exclude?; (2) once selected for inclusion, how should information be updated?; (3) who should do the selection and inputting of information?; (4) how should knowledge be organized so it is easily understood and easily found?; (5) how can the system be designed so that people can easily add or access information?; (6) how should people be rewarded for adding their knowledge to a knowledge base so that others can access it?; (7) how should people be rewarded for using the system? (Marsick and Watkins, 1999).

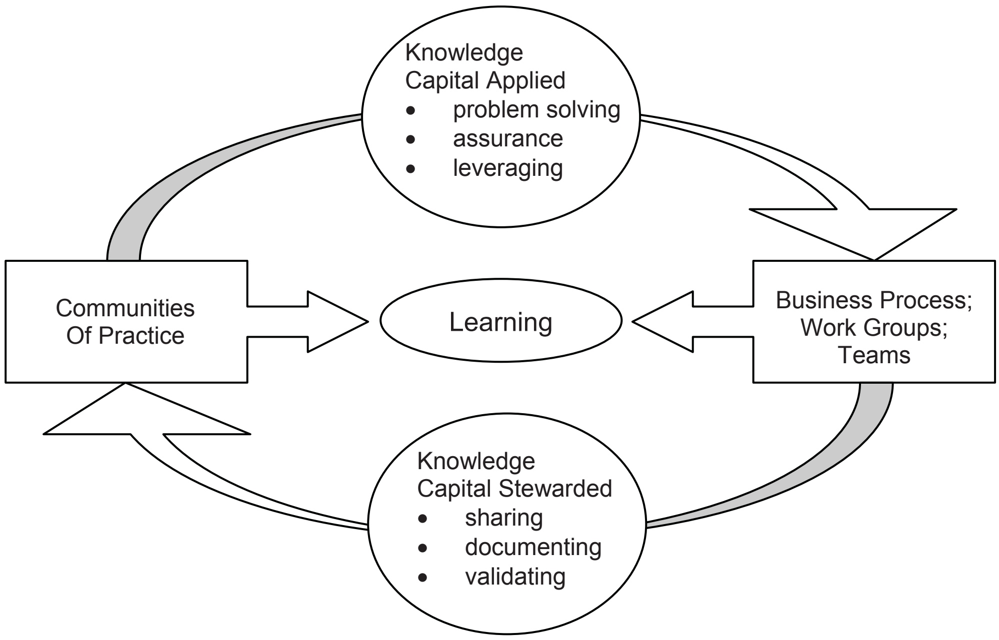
And a number of specific factors are playing a role in the quality of electronic knowledge systems: speed; simple log in and log out; user friendly navigation (surfing); good and simple search method; convenience in feedback; linking from knowledge to professionals: pointers to competencies of employees; actual and correct content (Bertrams, 1999). Two limitations of this repository view of knowledge management can be mentioned (Ackerman, Pipek & Wulf, 2003). First the transferred information is decontextualized, and this makes it not easy to apply to a current problem or situation without the help of experts. Ambiguity can only be overcome in face-to-face communication or interactions. Second ICT systems are not appropriate for the codification of tacit knowledge. Access to other people and/or experts is indispensable. In addition to ICT systems to exchange tacit knowledge expertise sharing, that focusses on the human components – the cognitive, social, cultural and organizational aspects of knowledge work – is needed. In relation to this Cohen and Prusak (2000) mention the importance of social capital, a company's 'stock' of human connections such as trust, personal networks and sense of community. Self-organized activities of organizations' members need full attention because sharing tacit knowledge requires face-to-face interaction and informal learning processes (Brown & Duguid, 2000) such as dialogue (Isaacs, 1999), apprenticeship (Lave & Wenger, 1991) and storytelling (Orr, 1996), of the kind that communities can provide.

Communities

A community is based on shared activities and a shared need of knowledge (Huysman en De Wit, 2002). Communities differ from teams. Teams are accepted and structured entities within an organization, which is not necessarily the case with communities. Apart from that, the make-up of communities may change, while the structure of teams often is fixed. Three types of communities may be distinguished, i.e. communities of interest, communities of purpose and communities of practice. Communities of interest develop because of a shared need for knowledge. They evolve organically around special issues, they surpass divisions, and whoever is interested takes part (Huysman en De Wit, 2002). Communities of purpose are temporarily set up by management to accomplish a specified task. Communities of purpose often consist of professionals that are specialized in a certain domain (Iske, 2002). A project team is a good example of a community of purpose. Communities of practice are organized around shared practices and actions (Lave en Wenger, 1991; Wenger, 1998). Examples of communities of practice at work are technicians that serve copiers for the same company (Orr, 1996), midwives that work in the same village, and butchers that work in the same factory (Lave & Wenger, 1991). Wenger (1998) says: 'Communties of practice are an integral part of our lives. They are so informal and so pervasive that they rarely come into explicit focus (p 7). Wenger, McDermott and Snyder (2002) describe communities of practice as groups of people that share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on a ongoing basis. A community of practice is a unique combination of three elements: a *domain* of knowledge, which defines a set of issues; a *community* of people who care about this domain; and the shared *practice* that they are developing to be effective in their domain. Wenger, McDermott en Snyder (2002: 27, 28) describe these three elements as:

- The *domain* of a community of practice creates the common ground and a sense of common identity. A well-defined domain legitimizes the community by affirming its purpose and value to members. The domain inspires members to contribute and participate, guiding their learning and giving meaning to their actions. Knowing the boundaries and the leading edge of the domain enables members to decide exactly what is worth sharing, how to present their ideas, and what activities to pursue. The existence of the community of practice is bound to the importance attached to the domain by its members. Once the domain loses its value the community of practice will cease to exist.
- The *community* creates the social fabric of learning. A strong community fosters interactions and relationships based on mutual respect and trust. It encourages the willingness to share ideas, expose one's ignorance, ask difficult questions, and listen carefully.
- The *practice* is a set of frameworks, ideas, tools, information, styles, language, stories, and documents that community members share. Whereas the domain denotes the topic the community focusses on, the practice is the specific knowledge the community shares, and maintains. When a community has been established for some time, members expect fellow members to have mastered the basic knowledge of the community. This body of shared knowledge and resources enables the community to proceed efficiently in dealing with its domain.

According to Wenger, McDermott and Snyder (2002) a community of practice is more than a website, database or a collection of best practices. It is about people that interact, learn together, build up relationships, while developing a sense of belonging and mutual commitment in the process. Working with others that share your overall view of the domain and nevertheless express their individual views on any given problem contributes to creating a social learning system that goes beyond the sum of its parts. Interpersonal realtionships are important. Knowing each other makes it easier to ask for help: you know who is likely to have an answer and you can feel confident that your request is welcome. Isaacs (1999) speaks of a dialogue here. During a dialogue experiences, mental models and skills are shared, which creates a collective intelligence - people together arriving at a shared understanding of a problem and a collective solution that combines the ideas of many people. In line with these observations, as far as knowledge exchange and learning is concerned, two main functions of communities of practice may be distinguished. On the one hand, a community of practice is a living context that can give newcomers to an organization access to competence and also invite a personal experience of engagement by which to incorporate that competence into an identity of participation. Communities of practice are a priviliged focus of acquisition of knowledge. On the other hand, a properly functioning community of practice in an organization is a good context to explore radically new insights without members being made fools of or getting stuck in some dead end. A history of mutual commitment to a joined enterprise is an ideal context for this kind of leading edge learning, which requires a strong bond of communal competence along with a deep respect for the particularity of experience. When these conditions are in place, communities of practice are a priviliged locus for the creation of knowledge (Wenger, 1998: p. 214).



Figuur 2. *The multimembership learning cycle (Wenger, McDermott & Snyder, 2002, p.19)*

For a knowledge creating organisation is essential that its knowledge, the communities (of practice, purpose and interest) and the business process should be carefully geared to each other. In a knowledge creating organization there is a strong entanglement between the communities (of practice, purpose and interest) engaged in knowledge and the business processes in which knowledge is applied. This is also called the 'double-knit' organization (Wenger, McDermott en Snyder, 2002). Practitioners that function both as community members and operational team members connect the competence of communities with the need of knowledge of teams and business units. In this respect a community differs from a centre of excellence, where specialists develop knowledge without being themselves involved in line operations. This 'multimembership' creates a learning cycle (Fig.2). Community members that also function in a team exchange with their community any skills they have acquired and any problems they have encountered in the team. Any newly acquired skills and solutions for problems are added to the 'practice' of the community and any unsolved problems may be discussed in greater detail. Subsequently, armed with new knowledge and possible solutions, the community members return to their team.

In this time of shifting market needs Wenger, McDermott en Snyder (2002) even see communities of practice as ‘foundation structures’ of knowledge creating organizations. Communities of practice are organized around knowledge domains and connect people from different units that are working in projects related to this domain. When teams, projects, markets, and formal structures organized around products and services are constantly changing, the domains of communities of practice and their informal voluntary structures may continue to exist, thus creating stability in an organization.

Controllability of communities by management

Communities are hard to control since the development of situated knowledge often occurs unconsciously and unplanned. Communities may be looked upon as strong informal connections for knowledge exchange. Managers, on the other hand, who are often focussed on formalized working and learning processes, tend to be less attentive to the development of knowledge occurring in daily interactions. Communities are a great challenge to management. They often depend on initiators that have to meet specific requirements. Since the life of a community often depends on the interest that the individual members have in it, they are hard to handle as a management instrument (Huysman & De Wit, 2000).

Though communities of practice are essentially informal and self-organisatory in nature, they will profit by cultivation and react to attention that respects their character: “You can’t tug on a cornstalk to make it grow faster or taller, and you shouldn’t yank a marigold out of the ground to see if it has roots. You can, however, till the soil, pull out weeds, add water during dry spells, and ensure that your plants have the proper nutrients. And while you welcome the wildflowers that bloom without any cultivation, you may get even more satisfaction from those vegetables and flowers you started from seed.” (Wenger & Snyder, 2000, p.143).

In the literature different ways to cultivate communities of practice are mentioned (Wenger, McDermott & Snyder, 2002; Wenger & Snyder, 2000; Cohen & Prusak, 2001). To identify communities or get them off the ground and preserve them in the course of time, managers should be keen to identify potential communities of practice that may enrich the strategic possibilities of an organization. Managers may offer an infrastructure that supports communities and enables them to apply their expertise effectively. Communities of practice are vulnerable: they are not legitimate and lack the budgets of established departments. In order to let communities fully flourish they might be incorporated into the ‘business’ and given specific support. One way of supporting communities is to provide them with official sponsors and supported teams in order to put tools and co-ordination at their disposal. Another way is to make infrastructure available such as experts from outside the organization, travelling facilities, meeting facilities and communication technology. An additional stimulus will be to recognize the efforts put in by employees for the benefit of communities. It is also important to support communities in paying attention to their added value. To achieve this, it will be necessary to support communities in their need to create events, activities, and relationships that help their potential value emerge and enable them to discover new ways to harvest it. The best way for a manager to estimate the value of a community, is to listen to the stories of its members, which can be collected systematically. Davenport and Prusak (1998) point out that outside people are often attracted to write down these stories. The employees themselves are often "too busy", are under time pressure or want to go on with their work. Employees' contributions are often restricted to what takes little effort and time. It is also important to support the creation of the rhythm of community events such as regular meetings, Web site activity and informal lunches.

Method

Research question

Although at present knowledge management, ICT and communities receive much attention, there has been little research into the value the combination of ICT and communities may have for knowledge management in practice. From the theory (Wenger, 1998; Wenger, McDermott, & Snyder, 2002; Ackerman, Pipek & Wulf, 2003) it becomes clear that communities that offer access to experts and direct contact between people at work can foster the exchange of tacit knowledge that the ICT systems of S Ltd. cannot offer. Therefore in this paper the following research theme will be explored: does attention for the combination of an ICT-system and different communities (of purpose, interest and practice) enhance the use of the ICT system and in this way preserve the passion for knowledge of the engineers of S Ltd.? Or: How can a knowledge intensive organization shape knowledge management with the aid of both ICT and communities? To answer this question we will ask ourselves: What kind of communities exist in S Ltd. engineering? How do these communities support the process of knowledge management in S Ltd. engineering? Can these communities encourage the use of the ICT system e-Knowledge? Can these communities be managed?

Selection case and respondents

The headquarters of S Ltd. has its seat in Germany. Most products that are sold in the Netherlands are developed and produced in Germany. More than half of the company's added value in the Netherlands is derived from project management, knowledge, advice and engineering, hardware and software development, manufacturing and assembly. A further contribution is made by logistics, training, installation and setting up of new machines, service, maintenance and repairs. In addition to selling products, S Ltd is specialized in providing total solutions. As a company S Ltd. has been interested in making workprocesses more efficient by implementing a knowledge landscape e-Knowledge as well as by developing and sharing knowledge about communities of purpose, practice and interest. Since e-Knowledge has not yet been fully used by engineers, S Ltd. is interested in the potential of communities to make the engineers more motivated to use e-Knowledge.

Within S Ltd. the research was done in two engineering departments of their Netherlands office at the Hague, i.e. the department of Chemistry, Food and Luxury Foods, Paper (CVP), and the department of Water and Infrastructure, Oil and Gas (WOG), which together have a staff of 50 engineers.

For the purpose of this research six projects were selected, i.e. three projects in the department of CVP and three projects in the department of WOG. Selection criteria were the availability of ongoing projects and the time available for observations. Another selection criterion was the presence in each project of newcomers and experienced engineers. From these projects four lead engineers and eight engineers were interviewed. From the eight engineers five were experienced engineers and three were newcomers. In addition, four lead engineers and three department heads were interviewd. Outside the projects 2 project leaders in knowledge management were interviewd, one stationed at The Hague and one stationed in Brussels (the Belgian office of S Ltd.).

All fifty engineers of CVP and WOG were involved in the evaluation of the Simatic community. The questionnaire was sent by computer to the engineers and after recall 37 questionnaires were sent back, which makes a response percentage of 72%.

Procedure and instruments

In order to gain an insight into knowledge processes in the community of practice of engineers, data about knowledge sharing between engineers on the projects were collected by interviewing engineers, project leaders and department heads. Besides, the new Simatic community was evaluated by means of an electronic questionnaire.

- For interviewing the engineers an interview guide was used that contained two sections. One section consisted of topics based on the conceptual framework of communities of practice, developed by Lave and Wenger (1991)[2]. These data show how beginning engineers acquire experience while participating in, and becoming members of, the community of practice of engineers. They illustrate what experiences, materials, and corporate culture, in brief what 'practice' engineers experience at S Ltd's, and how they become competent engineers. The second section contained questions on such topics as knowledge sharing, e-Knowledge, communities and projects. These are typically the elements from the engineers''practice' in which the emphasis is on knowledge.
- The interview guide for the department heads was based on the knowledge processes from Weggeman's knowledge value chain (Fig. 1). The different knowledge processes were the topics from the interview guide. The Management were asked what they thought these knowledge processes should be like for the work of the enigineers.
- The questionnaire used to evaluate the Simatic Community contained questions about the contents of the e-Knowledge system, and about the contacts of the engineers in and

outside the department. Other questions were concerned with knowledge processes such as questions about data collection, data codification, and data validation.

Results

The knowledge streams within S Ltd. engineering

Within S Ltd. engineering several initiatives are noticeable in knowledge processes. In Figure 3 the knowledge landscape (grey cylinder), the taskforces (= core teams), the projects, and the communities (of practice, purpose and interest, see grey rectangle) can be distinguished. In this paragraph we will describe how these initiatives connect and how they can support each other. The description is based on the data collected in the interviews with the two project leaders in knowledge management. It outlines the possible knowledge streams within and between the different departments. Some of these knowledge streams are already being put into effect within S Ltd. engineering, such as the formulation of skills (a knowledge chart listing the knowledge and skills of engineers), and the updating of skills when a course or project has ended. Other knowledge streams, such as the verification of best practices, have not been put into effect but are deemed desirable. The main assumption of Figure 3 is that knowledge is stored in the knowledge landscape and in the communities of practice, purpose and interest, thus making it available to all projects. This is the meaning of the fat grey arrow pointing downwards from the knowledge landscape to the projects. The projects are also in touch with the communities of practice, purpose and interest through its members, the engineers. The engineers working on a project may also be members of a task force or core team, so that the expertise of the core teams will flow to the projects. In this way the communities of practice, purpose and interest are accessible to all engineers of EPI ENGI (= S engineering). Depending on the goals of a community and the confidentiality of the matters exchanged or developed in a community, it may be decided to accept members from other divisions of S Ltd. outside The Hague.

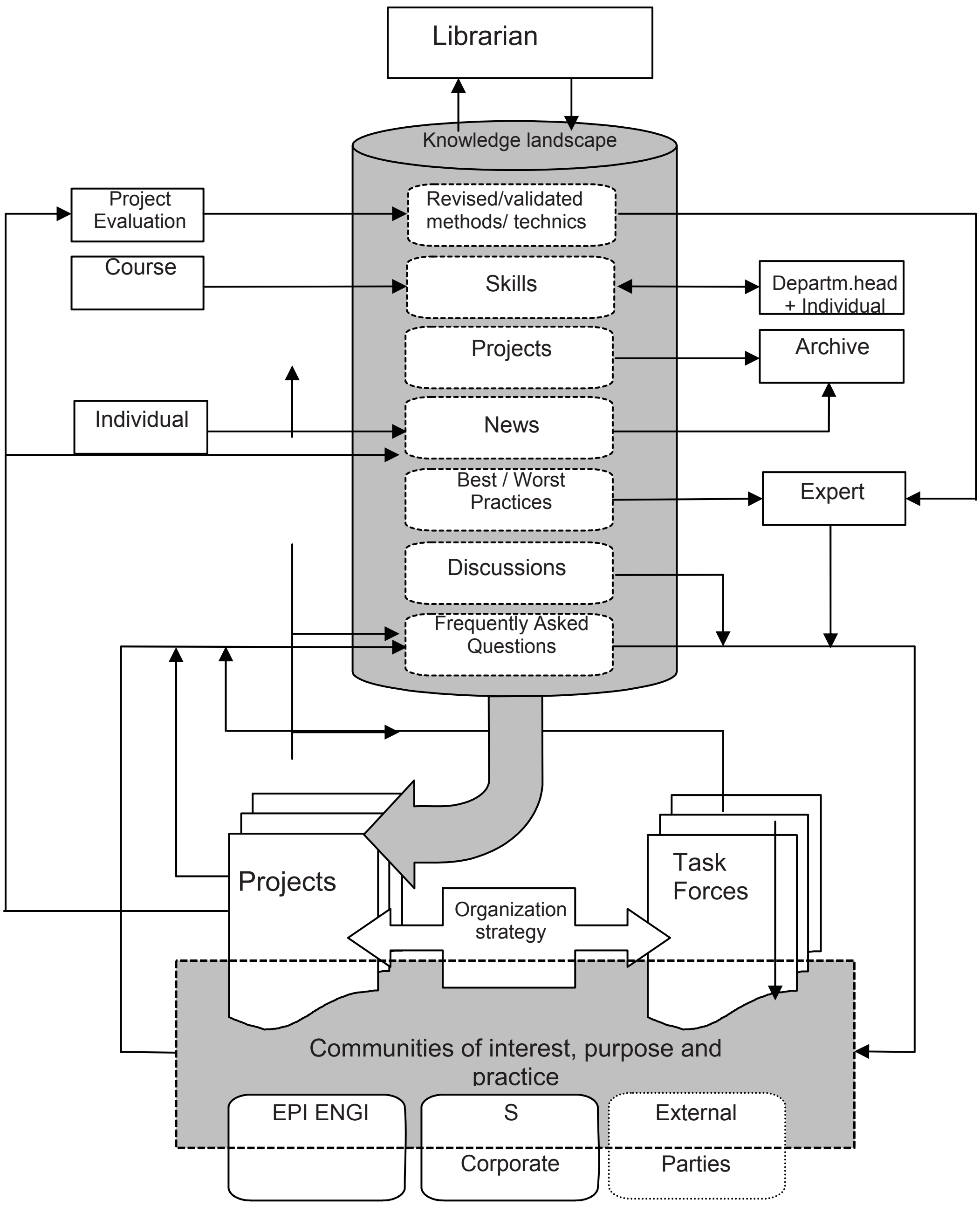


Figure 3. *Overview of the knowledge streams within S Engineering*

Another option is to involve external parties such as suppliers or customers in a community. The boundaries of a community are vague since the dimensions of a community are independent of the organization. The knowledge landscape e-Knowledge has been developed to support the projects. One of its aims is to provide projects, communities of purpose, practice and interest as well as task forces with a platform for storing and exchanging information. Another aim is to give individual engineers a chance to bring up a new item or to start a discussion, though an engineer is more likely to do so in the context of the project he is working on or the community of practice, pupose or interest he happens to be a member of. After having acquired new knowledge by taking part in a project or a course, the engineer will bring his skills (a knowledge chart with the knowledge and skills of the engineers) up to date. In this way any new knowledge will be accessible to all projects. As soon as the projects are ended, they are evaluated and subsequently included in a list of finished projects. From these evaluations best and worst practices may be derived, which are included in the knowledge landscape**.**

It may also be decided that certain methods or techniques are so good that they should be applied on other projects as well. Engineers hold the view that only the experts, the highly experienced enigineers, are qualified to revise submitted best practices and good methods and techniques for inclusion in the knowledge landscape. The official appointment of an expert for revision and validation is still a difficult issue. It is possible to include the revision task in a job description. Another option is to leave this task to experts that are interested and motivated to do the revision task on their own accord. To structure this process, however, a 'knowledge coordinator' or 'librarian' should be appointed. It will be the librarian's duty to deal with anything that happens within the knowledge landscape and to keep up to date with the developments in the knowledge domain within his department. This 'knowledge coordinator' will be put in charge of revising and validating any new knowledge in the knowledge landscape as well as updating the knowledge landscape of the communities of practice, purpose and interest. If necessary, he relies on the knowledge of experts. Revision and validation involves deciding on any new item whether it is interesting enough to be admitted to the knowledge landscape. Existing items have to be revised regularly to see if they are still valuable, and if not, they should be removed from the knowledge landscape. A second type of librarian is the system manager. He is the person in charge of the technical design and ICT support of the knowledge landscape.

The task forces (core teams) of the communities of practice, purpose and interest can be made responsible for preparing an overview of the Frequently Asked Questions within their knowledge domain. Questions about the Simatic Community, for example, are not relevant to a community that is engaged in project management. This is another reason for linking specific items of the knowledge landscape to specific task forces and communities. In practice this means that every group needs its own (protected) knowledge environment. Within e-Knowledge this is the virtual team environment, which is named flexteam.

The communities of purpose, interest and practice within S engineering

Within S Engineering Ltd. three types of communities may be distinguished, arranged in an order of decreasing formal structure and controlabillity by management, i.e. the Community of Purpose, the Community of Interest and the Community of practice. The groups involved within S Engineering Ltd. are the core teams, the Simatic Community and the Community of practice of engineers respectively. The Community of practice of engineers is characterised by their ‘practice’, the way in which the engineers work and communicate. This determines the knowledge processes and learning processes within S engineering.

The community of purpose: the core team

Within S Engineering the core teams are the communities of purpose. The core teams are engaged in the improvement of specified things or themes, such as offers, the coordination of assignments, work methods, products and systems, support of utilities or support of e-Knowledge.

According to recent research within CVP (S Ltd., 2002) the engineers believe that the core teams improve knowledge sharing and standardization, resulting into savings in costs and time. Yet the core teams still have to assert themselves because:

- The projects take a higher priority than the core teams. Since the projects are often more expensive than estimated, the time set aside for core teams is often used for projects.
- The fact that engineers often work with clients outside S Ltd. makes it particularly hard for core team members to find time to meet face-to-face.
- Members of core teams are assigned by management on the basis of their experience in a certain domain. Though this may seem a logical choice, an engineer may no longer be interested in this domain.
- Not every engineer is as enthousiastic and interested to take part in a core team. Less interested core team members see this work as a necessity.

The core teams are a suitable instrument for management to influence the knowledge processes within S engineering. Core teams are very formal. They can be set clear objectives, such as to validate items from the knowledge landscape that are older than one year.

The community of interest: the Simatic community

The Simatic community is the only existing community of interest within S engineering. At the moment there is a second, more recent initiative, the Teleperm Community. This community relates to older PLC systems that are set up within S engineering. The initiative to start the Simatic community has come from the engineers themselves. Some of them had already been working on a mail service, in which they sent members e-mail with information about new products, tips and tricks and so on. These engineers expressed the need to structure their activities in a community. First they formulated their objective, target group and domain: “Quicker and better access to the information you need in everyday routine”. To enhance its value the engineers sought to make this community cross divisional. Its field of activity is development tools. The name Simatic was derived from the Simatic product group, which covers all matters concerning the community. Next the Simatic community asked management for its approval and for a place within e-Knowledge (a flexteam) in order to collect information for the Simatic community. Management approved of a ‘flexteam’ for the

Simatic community, to which only the engineers of the CVP and WOG departments have access. Interested people from other departments may get a (temporary free) licence. In order to secure more resources for the Simatic community within S Ltd. and to increase its surplus value for the company, new members were also recruited, not only within the engineers' project team and within their department, but also from other departments and divisions. This community of interest makes it possible to acquire external knowledge and apply it on projects. Fom EPI ENGI this flow also runs to other departments of S Ltd., which may work out badly for certain tools that took EPI ENGI a lot of time and money to develop. For that reason management laid down the condition that these tools should only be available to the engineers. A second condition was that the surplus value of the Simatic community should be evaluated after three months. In order not to discourage the initiative, the management decided not to impose any further restrictions. The members of the Simatics community were held fully responsible. At present the Simatic community is still developing. The community's co-ordinators seek to enlarge its membership list, in order to increase the number of contributions to the flexteam. They also think about organizing face-to-face activities, which have not been realised yet. So far the members of the Simatic community have only communicated by way of the computer.

As part of the empirical research done for this article the Simatic Community was evaluated after one month. Most of the engineers (29 out of 37 respondents) of the CVP and WOG departments appear to know about the activities of the Simatic community. Thirteen engineers use the flexteam of the community on a daily or weekly basis. Though the quality of the contributions and information in the flexteam is considered to be good, the number of contributions leaves something to be desired. Another point is that not all contributions are easy to find. A very positive point, however, is that in a few cases information of the flexteam has already been put into effect. No longer having to answer the same questions again and again is seen as a possible advantage in the long run.

At present the surplus value of the Simatic Community is restricted to the contents of the flexteam. For a few enigineers (9 out of 29) the Simatic community is a means to contact people in or outside their department. In the future more surplus value of the Simatic community is expected from members meeting frequently and tackling problems together. In the future these meetings might be used not only to exchange information but also to tackle problems on the pc. Further presentations about products and systems during these meetings is an item mentioned by the engineers.

The biggest obstacle for taking part in the Simatic community is lack of time. Enigineers see activities for the Simatic community as something extra rather than part of their daily work. For some engineers the accessibility of the flexteam on intranet is a problem. Only a few engineers that worked outside were able to connect with the flexteam. For members of the Simatic community outside S Ltd. the licence costs are an obstacle.

Communities of interest are highly autonomous. Arising from shared work-related interests, they develop their own goals. A community of interest enables experts to find each other quickly, thus making it easier to develop new solutions and techniques. The informal nature of communities of interest makes it hard for the management to set them certain tasks, such as frequent validation of the contributions to e-Knowledge, to check their relevance. Of course the management can set up a core team to validate and clear e-Knowledge. Such a core team can use the expertise available in the community of interest when it is unable to validate a contribution by itself.

The power of a community of interest such as the Simatic community is that its members have joint interests outside e-Knowledge. E-Knowledge is only a means to an end. Several engineers of the Simatic community, for example, who had not contributed anything to e-Knowledge before, posted contributions to the flexteam of the Simatic community. This is why accumulation of knowledge and information in e-Knowledge has not been successful so far outside the flexteam of the Simatic community.

The community of practice: the engineers

The engineers form a community of practice. This community is less tangible than the Simatic community. A new engineer becomes a member of this community when he joins S Ltd. Socialization and learning in the community of practice of engineers occurs on the job. A new engineer learns by taking part in the daily 'practice' of the community, where he can observe colleagues and communicate with them, and work in a variety of situations. How fast a newcomer can develop into an experienced egineer depends on factors such as access to colleagues, the variety of work situations, the quality and availabillity of tools, resources, skills and knowledge needed in the work stuation.

In the introduction of knowledge management S Engineering decided on material knowledge bearers such as: hardware, software, documents and products. Initially there was no attention for any personal knowledge available in the heads of the engineers. By portraying the community of practice of the engineers, this article seeks to highlight the exchange of personal, tacit knowledge between engineers.

The role of communities of practice, purpose and interest in knowledge management

In this paragraph the role of the different communities is described on the basis of the adapted knowledge processes[3] from Weggeman's model (Figure 1): knowledge acquisition, knowledge codification, validation, knowledge sharing, knowledge application and reuse, knowledge evaluation. The data used are based on interviews with engineers and department heads. During the study it emerged that management and engineers had divergent needs and ideas as regards knowledge management. For this reason, the data about the communities of purpose, interest and practice are always preceded by data on what the management thinks about each phase of the knowledge chain.

Knowledge acquisition

Management

With respect to knowledge acquisition management attributes much surplus value to collecting knowledge from e-Knowledge.

Community of practice of engineers

For acquiring knowledge engineers have various tools at their disposal, i.e. manuals, the 'hotline' from S Ltd. (at the headoffice in Germany), a site with product support, news groups, discussion forums, e-Knowledge, and the modules and information on their own laptop. Any knowledge not available in S Ltd is acquired at courses or conferences, sometimes as part of a personal development plan. Acquiring knowledge is no problem for the engineers in S Ltd. since they form an open community, in which everybody is willing to share his knowledge with colleagues and explain it to them. On the basis of their personal network engineers know what person to contact if they want to know or learn something, making their decision on the experience and reputation of their collegues. Engineers strongly prefer contacting a colleague to consulting e-Knowledge. Since colleagues are not located far apart, this makes for an easy and quick exchange of knowledge.

Communities of purpose and communities of interest

Core teams acquire their knowledge through the engineers. These communities of purpose are highly suited for sharing knowledge across divisions and developing new knowledge. As far as the Simatic community is concerned, which is a community of interest, the acquisition of knowledge has so far been limited to the virtual team environment (the flexteam). In the future cross-divisional knowledge sharing is aimed for in order to involve other departments in the Simatic community.

Knowledge codification

Management

Management attaches much surplus value to the codification of knowledge through e-Knowledge. In this way knowledge will be preserved when engineers leave the department or S Ltd.. When it comes to translating implicit knowledge into explicit knowledge, the management team sets a good example by using a flexteam to promote the communication between MT (management team) members.

Community of practice of engineers

In contrast to managers, engineers assign little surplus value to the use of e-Knowledge. Engineers hold the view that, since every project is unique, reuse of knowledge is severely limited. Engineers also find e-Knowledge not user friendly and, besides, they think their own work keeps them busy enough as it is. One engineer states that he doesn't codify all his skills because there are skills he doesn't want to use anymore, since he has been doing different work. For these reasons engineers hardly use e-Knowledge.

Communities of purpose and communities of interest

Core teams can play a big role in codifying and storing knowledge. This is presently done in the flexteam (virtual space in e-Knowledge) of the department concerned. In every department there are a few engineers that are actively involved in core team activities. The core teams are strongly department-related. The highly formal character of these communities of purpose allows management to set them certain tasks and objectives. This is more difficult with the communities of interest since they set their objectives themselves, within the strategy of the organization. Learning and securing knowledge in the flexteam of the 'new' Simatic Community has made a fairly good start. Contributions have been made by people that were not earlier active within e-Knowledge. The connection with the subject and the community feeling may in the future lead to codified knowledge being secured even better.

Validation

Management

The management is in favour of a structural approach to the validation process. It is suggested that someone be structurally allocated the task to judge the contributions in the knowledge landscape by topicality and contents. If in validating the items his knowledge should be lacking, he can resort to the core teams or to individual engineers having much knowledge in the field of a specific contribution.

Community of practice of engineers

Though there has so far been no systematic validation of items for the knowledge landscape, this has not led to any direct objections. It should be doubted, however, whether there is sufficient motivation on the part of the engineers to engage in knowledge exchange, since knowledge exchange is little used in the knowledge landscape. What has actually been designed, is the validation of the skills (knowledge chart) within the knowledge landscape. The engineering staff are themselves responsible for updating their skills, which are validated during a performance or planning interview with their department head. The reliability of this knowledge chart is sometimes disputed in practice. In spite of the directives on how to indicate the level of skills, some engineers label the classification of skills given by some colleagues as incorrect . After all, through their personal network they are also familiar with the skills of their colleagues. Engineers daily and unconsciously validate their implicit knowledge by observing how other engineers work and tackle problems. This particularly happens in the project teams.

Communities of purpose and communities of interest

Core teams (communities of purpose) can be appealed to for validation of all sorts of contributions in the knowledge environment that are relevant to the core team in question. It appears to be common practice for somebody to be appointed who is accountable for the contents and topicality of the knowledge medium. Within the organization S Ltd an engineer can be made responsible per medium (such as the knowledge exchange of a flexteam). Another way is to set up a separate core team that is to engage in all these validation activities. Within the separate communities of interest and communities of purpose this is usually arranged by the co-ordinator. He supervises the contents of the virtual team surroundings, approaching the members on validation whenever he doubts the topicality or quality of any contribution.

Knowledge sharing

Management

As far as sharing knowledge is concerned, the management also attributes a big role to the knowledge landscape and the flexteams. It has clear ideas as to how the knowledge landscape is to be approached according to a specific procedure. This includes raising much used best practices (BP) to methods and techniques (MTT) (see Figure 3).

Community of practice of engineers

When it comes to sharing knowledge within S engineering, it strikes one that engineers are highly willing to help a colleague. Whenever somebody comes around with a question or a problem, time is usually directly made available to help the other or at least answer him. On the issue of sharing knowledge outside engineering opinions of the engineers differ. A large part of the engineers and management fear that expensively developed knowledge and tools of S engineering will leak away to other departments. If this knowledge and these tools were used by these other departments, this would damage the competitive position of S engineering. This lack of trust acts as a brake on cross-divisional sharing of knowledge.

As to sharing knowledge through codification, engineers feel the need to know from whom a certain contribution or module (in e-Knowledge) comes. This has got everything to do with the quality of the module and the confidence and reputation the engineer concerned enjoys. Some engineers have the need to look at problems together and to see how the other handles them. In their view this would lead to faster and better solutions.

The acccessibility of intranet is a limiting factor in sharing knowledge through e-Knowledge. During the activities on location the intranet is often not accessible to the engineers. Besides, engineers often lack the time to engage in activities related to e-Knowledge. Sharing implicit knowledge mainly occurs during regular activities. Mentors are allocated to new engineers to help them find their way within the organization and acquire knowledge about it. To improve the learning effect for the new engineers, experienced and less experienced engineers are put together on projects within S engineering. The same happens with the experienced engineers, where people from different specialisms are put together. So transfer of knowledge within S preferably occurs through face-to-face communication and socialization, i.e. the direct transfer of implicit knowledge. Explicit knowledge available in a system can support this process. Through the skills (a knowledge chart) available in the knowledge landscape it is possible to trace engineers that posses the knowledge desired. Within S engineering the scope of knowledge transfer through communication is limited to the direct environment of the project team and the department.

<u>Communities of purpose and communities of interest</u>

The members of the core teams (communities of purpose) periodically come together to discuss the latest developments in their 'field'. Their findings are communicated through the flexteam of the department. It might be useful for the future to combine similar core teams of the various departments or bring them into contact with each other. This will enable them to grow into cross-departmental and cross-divisional networks, in which knowledge can be developed and shared. Within the Simatic Community, the 'new' community of interest, sharing knowledge outside the virtual team environment has not yet come off the ground. This sharing is essential for building up a common history, which also enhances involvement with the community. People are easier to approach through e-mail or the virtual team environment if they have had physical contact earlier. The power of a community of interest lies in the involvement with subject or domain, which is a motivating factor. Besides, communities are eminently suited to bring together people of different departments and divisions on a specific topic. At present the co-ordinators of the Simatic Community are highly active in recruiting members outside S engineering.

Knowledge application and reuse

<u>Management</u>

The management believe that it is possible to apply and reuse existing modules. Though the projects are unique, within several projects for instance a drive mechanism or a crane is used. In this context the management also sees possibilities for standardization. "70% of all cranes are similar, it is the last 30% that makes a crane a dock crane." The same goes for the exchange of shared installations between projects.

<u>Community of practice of engineers</u>

Though engineers believe that every project is unique, a large part of them do not see the point of reusing existing modules of others. Moreover, they often prefer redesigning a module in order to make it better than the previous one, using the latest state of the art and their present knowledge. As to reusing modules of others, engineers point to the danger that, due to lack of insight, certain knowledge is not sufficiently understood or correctly applied.

According to the engineers, one might arrive at a kind of compromise whereby the working of the model is outlined, but for details contact can be made with the engineer that has brought in the module. Application and reuse of explicit knowledge within S engineering mainly occurs at an individual level. Via his laptop an engineer keeps his old modules and information of completed projects, knowing that they may possibly come in handy for future projects. Within the CVP department operates a core team that is engaged in centrally collecting them. Collective reuse of explicit knowledge is a more complicated matter. Not until the collected modules and information in the knowledge environment are accepted by the various engineers, have they become organizational knowledge and will they begin to be generally reused. In fact, the application of implicit knowledge occurs automatically, provided it is stimulated by a rich (working) environment in which there is collaboration with experienced colleagues and specialists.

Communities of purpose and communities of interest

The use and reuse of knowledge from the core teams (the communities of purpose) will mainly occur through the contents of the flexteam. The engineers may also approach the members of a certain core team with questions. This can be done through knowledge exchange, but also by directly contacting core team members. Whether the knowledge of the flexteam will be widely used by the engineers, will be dependent on the involvement with the core team concerned and the trust in the quality of the contributions. As to the reuse of explicit knowledge through the flexteam, the core teams depend on the quantity and quality of the items in this virtual team environment. In addition, these communities of interest and purpose are dependent on their position in the organization. Though the Simatic community has officially been affirmed, it is still no crucial unity; the use of the community and the number of engineers involved should still be expanded. Not until the members of the community physically come together and thus learn from each other, will the application of implicit knowledge of other engineers come off the ground. Though for the Simatic Community these meetings have not yet been worked out, the members of the core teams do meet periodically.

Knowledge evaluation

Management

The management sees possibilities for evaluating applied knowledge and the newly developed tools through description of best and worst practices once a project is being completed.

Community of practice of engineers

The evaluation of applied knowledge within S-engineering has not yet been given concrete shape. What is done, however, is that compliance with quality standards within a project is checked by means of a project audit. According to a few engineers, a possibility to evaluate the application of existing knowledge in practice is looking over the shoulders of the person that reuses the existing module or knowledge.

Communities of purpose and communities of interest

Feeding back the applied knowledge to the core team makes sense, in particular, if what comes out of this knowledge is at odds with the ideas and experience of the engineers. To secure the contents of the flexteam, new findings and experiences ought to be fed back. As to the application of knowledge from the community of interest, a similar approach might be adopted. This also depends on the needs of the members of the Simatic community.

Conclusions and discussion

An important assumption of this study is that with knowledge management two forms of knowledge have to be taken into account. On the one hand, there is explicit knowledge, which can be transferred with the help of an ICT system and, on the other, there is implicit knowledge, which is expressed in the experience and skills of engineers and which is acquired, in particular, in professional practice. For knowledge management this means that pure technology led knowledge facilitation is insufficient. Yet so far S Ltd has put much emphasis on managing explicit knowledge e.g. with the help of e-Knowledge. In the empirical research this one-sided attention to managing explicit knowledge is found back in the views taken by management on the use by engineers of the knowledge landscape e-Knowledge. As a result the knowledge landscape has hardly been used by the engineers to share their knowledge. It emerges from literature that communities (of practice, purpose and interest) can play a central role in the knowledge management of both implicit and explicit knowledge, because they offer opportunities to expertise sharing and informal learning through working together with experts and/or workers with much experience (Wenger, 1998; Wenger, McDermott, & Snyder, 2002). This paper focusses on the question if attention for the combination of an ICT-system and different communities (of purpose, interest and practice) can enhance the use of the ICT system and in this way preserve the passion for knowledge of the engineers.

Research has been done in two departments of S Ltd to find out if this is the case in these departments, what role the various sorts of communities play in knowledge management and how the functioning of these communities can be further improved, also in the light of the fact that too little use is made by the engineers of the recently introduced knowledge landscape e-Knowledge

The engineers of two engineering departments of S Ltd make up a *community of practice*. They work together in projects. During their work they consult on how to deal with problems, exchange knowledge or develop new ideas. Young engineers learn from their older and experienced colleagues, who in turn learn from one another since they are specialized in different areas. Engineers pass on implicit knowledge to each other during practical work, sometimes consciously, sometimes unconsciously. S Ltd might encourage implicit knowledge transfer further by making the engineers more aware of this process and by bearing in mind, when setting up project teams, that these should at any rate include both inexperienced and experienced engineers with different specializations. According to Nonaka & Nishiguchi (2001) crossfunctional teams (of engineers) encourage knowledge exchange through dialogue. Engineers' mental models and skills are converted into common terms and concepts by means of two processes. Engineers share the mental model of others and reflect and analyze their own. Ackerman, Pipek & Wulf (2003) mention this as expertise sharing. To create crossfunctional teams the knowledge chart in e-Knowledge can be used. The engineers are a highly open community, in which everyone is willing to exchange knowledge with each other and to help others. This good atmosphere, by Nonaka & Nishiguchi (2001) labelled an atmosphere of 'high care' is a basic condition for knowledge exchange between employees. The trust that develops in such an atmosphere is the basis for active empathy (assessing and understanding what the other truly needs based on broad acceptance of the emotial lives of others) that is essential according to Von Krogh, Ichijo & Nonaka (2000) for establishing good working relationships – and good relations and in turn lead to effective knowledge creation. This openness can be further developed by compiling success stories of helping and support. These stories should be specific enough to include the point in the process at which the support was given, the nature of the support, and its positive result (see also Orr, 1996; Kleiner & Roth, 1997). Giving the engineers - now physically separated from each other per project - a greater view of each other's activities by removing the partitions between them, could further stimulate this openness. A very positive point is that the principle of multimembership (see Figure 2) is applied at S Ltd. This means that, while working on projects in practice, engineers are also members of several communities (of interest and purpose), with which they exchange knowledge and skills. Moreover, they have e-Knowledge, with which they can exchange knowledge. So within the community of practice of engineers the (implicit) knowledge and skills of the experienced engineers are shared with colleagues during work. In this way knowledge can continuously be secured at S Ltd . If this process proceeds properly, the departure of one engineer does not really matter, since there are always one or more engineers left that have (part of) the expertise of the departing colleague. Besides, it may be arranged that the exit talk held with every departing engineer is attended by an experienced engineer. Engineers prefer exchanging knowledge orally to sharing explicit knowledge through e-Knowledge, the reasons given for this being that in their view most knowledge used in projects is unique; reuse of knowledge without consulting the expert that created it may cause wrong application of this knowledge in practice; intranet is not always accessible when the enigneers work outside the company; e-Knowledge is not user friendly and up-to-date and that engineers just like to develop new knowledge and their own solutions. They believe that the use of e-Knowledge can be improved by indicating for best practices and modules which engineer supplied them, because knowledge from an engineer with a good reputation is eagerly reused. The importance of a good reputation has also been mentioned in the literature (Davenport and Prusak,1998; Cohen & Prusak, 2001). What is also needed, is a good validation of new knowledge that is stored in e-Knowledge. Modules should not be too specific since they must only contain knowledge that can be reused. It is also essential that e-Knowledge become user friendlier and more accessible and that the knowledge it contains be relevant and kept up-to-date. At this moment finished projects are evaluated insufficiently or not at all, due to lack of time. A possible solution might be to set up a core team that is occupied with this task, for instance by constructing histories of the course of the various projects and making them available through e-Knowledge as fast as possible (see also Wenger, McDermott and Snyder, 2002; Huysman and De Wit, 2000). It is concluded that e-Knowledge from S Ltd. lacks a number of essential conditions for a good functioning ICT knowledge system mentioned by Marsick & Watson (1999) en Bertrams (1999). The preference of face-to-face communication of the engineers should be further facilitated by the management through offering time and ‘natural’ places for communication to exchange experiences, tell stories and engage in social talk (Cohen & Prusak, 2001).

Further a close look was taken at the role of various kinds of communities in the process of knowledge management by S Ltd.

The great value of *a community of interest,* for instance the Simatic community of S Ltd., lies in the engineers being focussed on sharing their knowledge and information with each other. To allow them to do this easily from their workplace, the engineers have at their disposal a sheltered knowledge environment on e-Knowledge, the flexteam. Such interaction in a virtual place is also mentioned by Nonaka, I., & Nishiguchi, T. (2001). That engineers who are members of the Simatic community are increasingly more willing to put their knowledge into e-Knowledge is due to the interests of the engineers themselves. Engineers that were not active in e-Knowledge earlier, now do use the virtual team environment, the flexteam, which also satisfies the management's wish to make knowledge independent of individual persons and secure it in a system. The processes involved in knowledge validation also come under the responsibility of the Simatic community. The engineers jointly see to it that the contents of the virtual team environment remain up-to-date. Should the domain of the Simatic community no longer be relevant in the long run, it will simply cease to exist.

What makes the *communities of purpose*, such as the core teams in S Ltd., valuable to management is that, unlike communities of interest and communities of practice, they are fairly easy to direct and control. Management should preferably facilitate only the latter two types of communities. The added value of core teams is that, on the one hand, they are highly suited for knowledge exchange between departments and, on the other, that using their specific knowledge they can validate any contributions supplied by communities of interest for inclusion into in e-Knowledge. A co-ordinator (or core team) might be appointed, who is to be made accountable for the contents in the knowledge landscape, and who allocates to certain core teams any new knowledge to be validated.

It is the *task of management,* in particular, to encourage, support and facilitate community initiatives and, if possible, to direct them. Support may be given e.g. by providing time, physical space and cyberspace to already existing communities and to any new initiatives in this field, which may be further directed by setting up core teams with specific goals. Face-to-face contact appeared to be essential and preferred by the engineers of S engineering. So extra support of time and space for face-to-face communication, social talk, exchange of stories, and experiences between engineers to built connections and to strengthen commitment, involvement and trust must have priority in the support of knowledge and expertise exchange. This approach fits in the culture of 'openness' that already characterizes the community of practice of the engineers at S Ltd..

Reviewing the role of various kinds of communities in the process of knowledge management at S Ltd., we arrive at the following conclusions. The community of practice of the engineers has an important role in expertise sharing, the exchange of tacit knowledge; the Simatic community, a community of interest, plays an important role in motivating engineers, e.g. to use e-Knowledge and the core teams; finally, the communities of purpose play an important role in validating knowledge for inclusion into e-Knowledge and the dissemination of knowledge among departments. An essential result of this study, that adresses the original problem of S Ltd. that engineers hardly use the (new) ICT system, is that taking part in a community of interest based on their own interests seems to be a powerfull motivator for the engineers of S Ltd. to start using the (new) ICT system. This means that to preserve the passion for knowledge of engineers, the introduction of a new ICT system should include the possibility to form new communities of interest that are geared to the interests of the engineers.

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