IMPLEMENTATION OF TACIT KNOWLEDGE PRESERVATION AND TRANSFER METHODS

B. Faust
Nuklearforum Schweiz, Switzerland

E-mail address of main author: brigitte.faust@nuklearforum.ch

Abstract. With their different characteristics explicit knowledge, implicit knowledge and tacit knowledge need individually adapted methods for their preservation and transfer. The paper limits its scope to those two elements of knowledge management having proven to guarantee the most return on invest - together an improvement of the access to knowledge. Besides, for their successful implementation they have to be incorporated into a holistic knowledge management system or better, into an integrated management system. Mentor program and observation have been applied more frequently than thematic seminars gathering tacit knowledge from experts, virtual reality and half-standardized interviews. The mentioned methods will be discussed in detail and their application dependent on the type of knowledge explained illustrating their merits and demerits.

1 BACKGROUND AND DEFINITIONS

The loss of knowledge does not only threaten the safe and economic operation of nuclear power plants, but has also negative effects on the socio-political system of a country. Transparent external communication is of paramount importance for gaining trust and thus a positive perception on the part of the public. 80 % of the most important knowledge is unconscious and only 20 % can be found in memos or books. The nuclear industry now has realized that ageing workforce represents an issue with safety and economic relevance. Knowledge preservation and transfer are therefore required to be considered within knowledge management (KM). The stakeholders who may profit from systematic KM are operators, industry, research institutes and universities, authorities, international organizations and the public. Besides, KM in terms of evaluation of research results does not only improve innovation, but also the process of decision making and helps increase public awareness for the efficient and transparent communication.

KM includes the whole organization of knowledge, beginning from the identification of information and ending with the evaluation of knowledge. Actually there is no common understanding of all these terms. Here, knowledge transfer (KT) is considered as that part of KM which refers to the transmission of explicit, implicit and tacit knowledge from a person or organization to one or several people.

2 STRATEGY AND THEORY FOR MODEL DEVELOPMENT

The most important knowledge elements are preservation and transfer, identification and development and finally, evaluation and application. Working within a knowledge cycle all of them serve for optimizing functional, organizational and methodological or process-related knowledge (see figure 1). Organisational knowledge is related to the organisation itself, while functional knowledge is required to perform predefined tasks and methodological-process related knowledge helps perform them.

When important knowledge is detected, it should be documented to allow its transfer, especially if the predecessor is no more available. The herein used methods differ in the possibility of doing so and dependent on the characteristics of knowledge.
Figure 1: Knowledge circle including the most important elements within knowledge management
All knowledge elements deal with explicit, implicit and tacit knowledge.

Explicit knowledge implies declared knowledge, i.e. knowledge being conscious to the knowledge bearer. That is why it is not a problem for the employee to tell about rules and obviously learned facts. Very often, this type of knowledge is already written down in books, journals or memos. This is not always for implicit and tacit knowledge. Besides, the preservation of explicit knowledge can be performed independently from its transfer.

In contrast to this relatively accessible information implicit knowledge is difficult to reveal, but it is still possible to capture. Usually the knowledge bearer cannot recall this knowledge by himself, because the information is too obvious to him. When somebody is asked, what he is doing in the morning, he might answer “getting up, taking a shower, having a coffee, checking the emails…” without thinking about that he first has to get undressed to take a shower, without thinking about the single steps when making a coffee and without thinking about switching on the computer before reading his emails. This kind of knowledge can only be detected by observing or asking in more detail.

The third type of knowledge, namely tacit knowledge, is the most difficult for transfer. Tacit knowledge contains experience based knowledge about topics such as how to ride a bike or how to talk. Tacit knowledge of an employee is for example the way how to persuade other people, how to behave in different situations or how to organize a meeting. Tacit knowledge cannot completely be explained, since it is wholly embodied in the individual, rooted in practice and experience for which cognitive schemata are required also being referred to as “mental models”. It is expressed through skilful execution, and transmitted by apprenticeship and training through watching and doing forms of learning [1]. Whereas those technical elements, i.e. concrete know-how, crafts and skills, can be transferred by observation. The cognitive part of tacit knowledge, namely believes, intuition or personal values need special effort to be extracted.

These three types of knowledge can be compared with an iceberg (see figure 2). The iceberg’s peak will be seen first and without any problems. This is the explicit knowledge. Below it, there is the implicit knowledge, which can be seen too, but needs a closer look. At the bottom – under the water – there is the tacit knowledge, which cannot be seen but only assumed.
3 APPLICATION OF THE MODEL

KM should be integrated in the daily work processes and better in a holistic quality management system (see figure 3).

Strategic KM has to be defined by the management, since they want their ideas to have realized by operative KM. When introducing a concept for KM it has to be taken into account that all employees should be supported in that they can perform their task successfully. In order to become experts within their own working area, they need explicit, implicit and tacit knowledge not just being developed by knowing the data and signs from a check-list. Nevertheless it has to be admitted that the latter are required to gain the required expertise.

Operative KM works just the other way round e.g. increasing the value of „raw data“ by adding information about its production and location. If this information in a second step is enriched with expert experience and creativity, background data and information context, then we obtain knowledge.
So, raw data are e.g. to be found on a list of components within a partial system. An explanation informing about their location and role within the whole system makes information out of data. An additional enrichment by some simultaneous categorization creates knowledge (see figure 4).

![Knowledge Management Diagram]

*Figure 4: Concept and Realization of knowledge management [3]*

Methods, operations, tools and techniques for implementing the elements of the knowledge cycle should be developed dependent on the knowledge characteristics, the applying persons (so do operators need other knowledge than structural engineers) and dependent on the overall goal. A knowledge matrix of all organisational units is helpful to identify the most crucial knowledge areas and to prioritize them. The inclusion of nuclear KM in an integrated quality management system is strongly recommended.

The speciality of nuclear knowledge is that it is both, complex and long-term. Furthermore it covers various disciplines and requires international cooperation in order to allow its efficient management. Since knowledge transfer is an important part of KM and not only the plants are ageing, but also the workforce, it is of paramount importance to link it with personnel development! This publication limits its scope to knowledge preservation and KT. Together with an improvement of access to knowledge in general knowledge they have proven to guarantee the most return on invest within KM.

4 METHODS FOR KNOWLEDGE PRESERVATION AND TRANSFER

For knowledge preservation and transfer with respect to a collective readership or audience there are several possibilities in principle being different from that for individuals. Electronic and written memos, journals and books provide expert knowledge for a wider group of people. The same applies to expert systems, newsgroups, videos and info-servers all of them being hierarchically structured in order to allow for search- & navigation from advanced web technology.

Ontology based portals contain a map and/or matrix with databases gathering functional, organizational and methodological or process-orientated knowledge. Since portals are only in part helpful for solving concrete problems, more individual methods are required to help preserve and transfer as much implicit and tacit knowledge as possible. Dependent on the different knowledge characteristics they have advantages and disadvantages [4]. According to Nonaka’s theory the process of knowledge conversion proceeds through four different modes [5]:
• Socialization – conversion of tacit knowledge to tacit knowledge (individual/team)
• Combination – conversion of explicit knowledge to explicit knowledge (organization)
• Externalization – conversion of tacit to explicit knowledge (individual) and
• Internalization – conversion of explicit knowledge to tacit knowledge (organization)

Socialization aims at transferring tacit knowledge face-to-face through interactions, imitation and practice. By sharing experience, individuals learn and gain a sense of competence e.g. by observation or mentoring even in the absence of language. They imitate thereby creating their own mental models. Since in this way problems are viewed from various angles, better solutions may become available.

The combination mode of knowledge conversion embodies the aggregation of explicit knowledge in meetings or conferences. Here, individuals or a group categorize and combine it in order to merge and then shape a new and enhanced conception. Such reconfiguration helps create new ideas.

Externalization references the translation of tacit into explicit knowledge involving the reification of a mental model into a concrete concept. Metaphors being based on two different or even contradicting concepts incorporated in one image or word may efficiently assist individuals in explaining concealed or tacit knowledge otherwise being difficult to articulate. By forming impressions based on “imagination and intuitive learning through symbols” metaphors help create networks of related concepts to enable a learner understand abstract, imaginary concepts, the way of thinking.

The conversion of explicit to tacit knowledge, i.e. internalization, occurs through a series of iterations in which individual concepts become concrete and ultimately absorbed as an integral belief or value. Whereas externalization utilizes metaphors to facilitate knowledge conversion, internalization represents an active process of learning. Here, explicit knowledge is shared collectively and gradually translated into tacit knowledge by interaction or by trial and error processes.

“Tacit knowledge is thus mobilized through a dynamic entangling of the different modes of knowledge conversion” [5]. Organizations should motivate personnel to take part in this process, since explicit knowledge has to be transformed in tacit knowledge in order for cognitive skills to develop. While each of them being able to create new knowledge these four knowledge conversion modes are more or less active or passive in nature. Therefore a hierarchy of methods for knowledge preservation and transfer from passive to highly active is suggested in order to smoothly adapt to the needs for learning [6]. The increasing growth of such “deep smarts” will be illustrated by figure 5:
For knowledge creation a continual dialogue between tacit and explicit knowledge is of paramount importance. Both, pure combination (explicit-explicit) and socialization (tacit-tacit) have demerits. An interaction between individuals and, more specifically their commitment, belief or value system in interacting with each other, play an important role in developing new ideas and concepts.

There is still one problem: What shall be done, when the predecessor is not available any more? There are a lot of reasons why this can be the case. Mentor program, observation and job rotation are methods which, under normal circumstances, are not documented (see chapter 4.1 and 4.2). The video together with the interview and the report are, however, the only methods for which documentation is planned. They will therefore be outlined in chapter 4.3 and 4.4, respectively.

Videos can be watched as many times, by as many people as desired and, whenever wanted. They can finally be an integral part for the establishment of a virtual reality system. The use of simulations from role-playing and case studies to virtual reality games permit learners to fail – and thereby learn – without repercussions. The documentation of half-standardized interviews can be read as many times, by as many people as desired and, whenever wanted. It allows capturing explicit and implicit knowledge and to some extent even tacit knowledge.

4.1 Mentor program and observation

A mentor program may enhance the availability of a leaving employees’ know-how more than written reports. Usually the predecessor shows him the ropes for some time, for example for a period of three months. They are working in parallel, so that the successor gets an insight in the working method, benefiting from the advantage of asking questions right away when problems are arising.

Gathering experience from practice-based wisdom does not only consist of directives, presentations, seminars and lectures. However, “stories with a moral”, “rules of thumb”, “Socratic questioning” (one-to-one-questioning and dialogue with the help of a knowledge coach) or “learning by doing” do significantly increase deep smarts [6]. Experts cannot structure all their knowledge in words and therefore may only help individuals create mental armatures on which to build their own knowledge. Tacit knowledge has to be re-created through the process of guided experience, i.e. through “learning by doing”. Intelligent people can develop competence within a couple of years, but truly deep smarts are gained only through ten or more years of diverse active learning experiences just as skilled engineers, surgeons, masons or teachers do [6].

People learn more experience-based knowledge from stories than either rules of thumb or lectures. Stories provide the context together with vivid details that lodge in the mind longer.
than straight lecture or generalities and so enhance explicit knowledge with implicit. Socratic questioning such as “why? How do you explain? What then…?” further engages a persons’ brain being quizzed and arouses interest. Stories stir his emotions thus increasing his memories’ absorption capacity.

Socrates (470 -399 B.C.) says that “you can become a better lifelong learner just the way I and my friends did in the 5th century in Athens” [7]:

- Ask open-ended questions rather than requesting specific information thus inviting the other person to open up and reveal what they know.
- Touch with yourselves’ deepest values
- Apply metaphors to break through rigid thinking jostling it out of the usual channels
- Think for yourself, your own thoughts and avoid falling back on received wisdom to guide your life
- Learn together since all of us are smarter than any of us
- Create your life being prepared to break through your present armour by opening yourself to the next stage of growth, for new growth to occur.

Observation is useful if direct a concrete personal involvement is impossible. It allows transferring tacit knowledge, even though less than may be transferred by a mentor program. It is especially helpful together with discussion forums such as communities of practice or electronic “meeting rooms”. NASA has investigated in its study four types within “learning by doing” in form of guided experience, namely practice such as music or athletic coaching, observation such as the attendance at a critical meeting, problem-solving where the protégé gets feed-back from the coach and experimentation where a novice is provided with the opportunity to perform experiments himself [7].

4.2 Thematic seminar gathering tacit knowledge from experts

A possible approach of gathering more or less experience-based thematic knowledge is the organization of a seminar thus preserving at least some of a retiring experts’ know-how. One may create some sort of topically condensed report containing the most important items and "rules of thumb". Thus the younger generation/new-comers are helped better grasp the essence of available knowledge (where should I look first? Who is it worth to ask and which experts are reluctant?). Such a procedure will not replace but rather complement already existing documents on the subject matter.

Seminars of two or three days may be organized. The goal is either thematic or general. In the latter case an organizations' aim might be first structuring knowledge to define what type of knowledge is most important, i.e. critical when losing it, and second defining a common language. After having decided about the knowledge priorities a thematic seminar intends to exchange and share knowledge about a specific topic. Both types of seminars do not only serve for the enlargement of an organizations' knowledge with respect to technical specifications, but also with respect to other competencies such as knowledge about work processes, leadership quality, team dynamics, project management wisdom, general problem solving strategies and last but not least communication between the various disciplines. For achieving most success with the seminars, guidelines might help when summarizing important rules for their organization, realization and documentation.
Golden rules are composed of rules, directives and lectures, best design practices, rules of thumb and context knowledge in relation to all of them representing implicit and tacit knowledge (see figure 5). The latter go beyond sterile technical specifications or information, but are enriched with embedded wisdom from engineering practice, process improvement and lessons learned from incidents. This type of knowledge is most efficiently transferred by using metaphors, because by breaking through rigid thinking people can imagine a situation better. Pauses additionally improve human learning mechanism, since new knowledge has to be mentally processed and connected to existing knowledge.

Case studies may provide the learner with context information that facilitates an understanding of industry dynamics and the forces and power related to politics being indispensable for decision making. Tacit knowledge from project management insights being embedded into stories additionally helps improve the relationship between the colleagues by fostering a good organizational culture.

NASA is concerned about losing expertise as people retire. Rather than depending on “expert gurus” soon vanishing they try to rely on a shared knowledge community that does not retire but evolves with time. The KM challenge regarding human talent is not only how to capture knowledge as they leave the organization but how to build learning into all that they do while they are still working. So, when they are ready to leave, most of their knowledge is embedded into the organization, people, processes, and policies that remain. Such a system will both sustain knowledge and produce more reliable results. This is the goal of Goddard's learning practice system [7].

4.3 Virtual reality

Implicit and tacit knowledge contribute up to a percentage of 80% to the success of an organization. Improving their codification increases its dynamics and competitiveness significantly. Thus, it goes without saying that solutions have to be found to profit most from it even if mentoring is not possible. Tacit knowledge is non-quantifiable and often very subtle in nature since it is based on first-hand life experiences and shaped by beliefs and social forces. Acquiring such a "know-how" and "know-who" is similar to gathering experience from practice-based wisdom, also called deep smarts (see 4.1 and 4.2).

Real-life stories, case studies and simulation from role-playing may significantly contribute to this process and enhance an employee’s “deep smarts” and thereby re-creating tacit knowledge. Virtual reality (VR) games permit learners to fail and thereby learn without repercussions [8]. It helps grave knowledge in the human brain through its individual reproduction on the conscious and unconscious level. In this way it allows an efficient training of the capabilities necessary to perform specified tasks, i.e. to perform the right thing at the right time at the right location. This is done in an automated process without explicitly reflecting the actual situation.

VR increases the human ability and motivation to absorb new knowledge or to abolish inefficient and false working procedures by correcting them in a holistic and traceable manner. Allowing the participants to act, interpret and be creative in a concrete situation a person obtains knowledge just as is the case through direct and personal transfer. Implicit and tacit knowledge are strongly linked with intuition. For safety-related activities such as aviation or nuclear technology it is especially important to perform actions not only being error free, but also rapid and automatically. When recognizing and then coping with unusual situations where creative decisions are needed, the contributing people are not always aware of the underlying processes, since these are emotional, unconscious or subjective [8]. They
feel as having a sudden, inspiration being as quick as a flash. The sequences of work steps are not known in every detail and so have to be interpreted individually by every team member.

All these activities can be re-lived in VR games. While co-operating they create their own cognitive scheme, in order to memorize and anchor it for rapid access. Knowledge about why and when complex activities are adequate cannot be documented in check-lists, since it is tacit and experts are often not aware of its importance with respect to mutual coordination and smooth synchronization.

In VR the created virtual environment enables an individual to simulate his own reality. He can e.g. dive into component parts of a structured system with his whole personality so understanding details and interact neglecting the physical laws. The more senses are involved during learning and the more actively his brain is engaged, the better he may retain or remember and so, the better the result. Simultaneously looking at a text or picture, listening, feeling and acting significantly increase human absorption capacity. Stimuli leave their own mark in the human brain when being associated with emotions (strong desire or confidence to find the right solution). The reciprocal effect will be caused, i.e. blockade of the memory, when being afraid. However, the personal learning style has to be recognized as well. Here, in addition to visual, auditory, logical, spatial and kinaesthetic people have different capabilities when learning in a group and learning alone as an individual.

VR permits interactive experience taking place in an unconscious manner, i.e. without explicitly thinking about it. The learner can expose himself to the authentic reliving as many times as he wants to and without risk. Studying experiences on the part of any third parties or reading handbooks does not guarantee the same intensity. Such an active learning makes them increase their own flexibility.

4.4 Half-Standardized Interview

Half standardized interviews allow capturing explicit and implicit knowledge and to some extent even tacit knowledge when being conducted by trained interviewers [9]. They elicit knowledge, experience and personal perceptions relating to work processes and organization. An important aim is KT to the successor and organizational learning. However, a successful application of the interview technique in combination with a written experience report is a challenging task.

The first problem relates to the question who should lead the interview. If an interviewer trained in interview techniques comes from another area of expertise than the interviewee it is recommendable that the interview is not conducted only by this interviewer, since he might not be able to understand all the explicit knowledge reported by the interviewee. On the other hand, somebody with the necessary knowledge in the specific area might not be trained in
carrying out interviews. So, the idea that two interviewers are indispensable seems to be logic (see figure 6). Having two different functions they contribute to the success of capturing knowledge: first, elicitation of experience-based knowledge is performed by the trained interviewer; secondly, detailed investigation of technical details is performed by a colleague from the technical department with the same area of expertise [10].

Still, interviewing with two interviewers at the same time will not be advisable, because in this way the atmosphere can never be relaxed. Besides, the interview can be better structured with only one interviewer because two interviewers might interrupt each others’ thoughts with their questions. This would give the impression that the interview is unstructured and chaotic.

The second problem relates to the question when the retiring person should write the report. If the report is written before the interviews, the interviewee might answer many questions referring to what he has written down already. However, while talking, additional ideas might cross his mind and the interviews’ content is not restricted. By asking questions, the interviewer obtains a thorough insight of the subject. It is not easy to request the interviewee re-telling everything again. Some interviewees might even take out their report and read the answer to the question aloud. That is why retiring employees are recommended to write the report after the interview.

In spite of the necessary structure, in half-standardized interviews there are only a few fixed questions – primary questions – which have to be asked in the given order to guarantee at least a rough structure. These are supplemented by secondary questions being posed freely dependent on the context. Allowing a benefit from “Story Telling” such half-standardized interviews represent a well investigated method to gather implicit and some tacit knowledge in a pleasant atmosphere [9], [10] and [11]. Both kinds of questions are incorporated in an interview-guideline, which ensures that all important subjects are included. The extracted experience-based information is intended to provide added value to both, the successor when e.g. gathering supplementary implicit knowledge and to the organization in form of “potential for improvement”. Already Davenport and Prusak emphasized that reciprocity and trust are important for the willingness to exchange knowledge [12].

If the interviews will be carried out in the future, two more thoughts have to be considered: on the one hand, a discussion whether the interview should be voluntary or obligatory is required. If the interview is dictated by the management, some employees without any interest in this interview might refrain from contributing to a successful interview. On the other hand, an adequate interviewer has to be selected: a person who is already working in the organization has background information and so, mutual understanding is easier. But it might also be difficult to interview a colleague from the same department. Also, the interviewee will abstain from telling organizational problems, since he is aware of working together with the interviewer until he is leaving. These problems could be solved by outsourcing. The interviewer should then come to the organization, just to carry out the interviews. The results could then be discussed with a contact-person in the organization.

5 CONCLUSIONS

Many KM-Initiatives have failed due to the lack of specified methods for conserving tacit knowledge. In contrast to mere information, explicit, implicit and tacit knowledge is dynamic and continuously changing. When planning for the future this fact should be considered. The implementation of KM requires an exact definition of its elements together with its characteristics so, that they are consistent among the users. The knowledge elements for individuals should conform to each other and integrate explicit, implicit and tacit knowledge.
Good tools and appropriate IT-infrastructure are important, but the best way for efficient identification, transfer and development of knowledge will always remain the human being. The management should be aware of this fact and not try to substitute personal contacts by information technology in form of enlarged databases. Beside mere knowledge extraction knowledge application both at its source and within communities of practice throughout the organization should be facilitated.

The informal exchange of ideas among the employees near the “coffee-machines” remains an optimal source of actual issues [12]. The herein produced costs might increase thus avoiding that short term goals are met. However, a good organizational culture can develop. For achieving long term goals this is most profitable. The fact that KM is useful might not be obvious to individuals and, therefore incentives are of predominant importance. Honouring good knowledge contributions could be carried out by distributing e.g. concert tickets or restaurant vouchers.

In the same way quantifiable targets should be allocated to KM and their success verified with the help of check-lists tracking the commitment of the employees. After having convinced the audience at project and line management, this has to be done also at working level, since here KM should facilitate life. Therefore feedback has to be gathered continuously.

Lessons learned are only possible if people do not have to be afraid to be penalized for their errors, since otherwise they do not report them. So, fairness, trust and understanding must complement each other. Organizational learning is not a theoretical construct, but means support and reinforcement of learning behaviour and knowledge sharing thereby assuring sustainability of an organization’s knowledge. Prevalent barriers of KM are lack of time with a percentage of 70 % and the attitude of „knowledge is power“. They might be overcome by adequate behaviour on behalf of the management. So have too many hierarchies proven to be abhorrent. Besides, transparency may significantly contribute to a good organizational culture and openness for change.

REFERENCES


