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KNOWLEDGE MANAGEMENT AND LEARNING CULTURE IN DISTRIBUTED ENGINEERING

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Abstract

The first wave of Knowledge Management was mainly technology driven. The current second wave focuses on behaviour and culture with concepts such as Communities of Practice. This paper proposes an integrated socio-technical framework for knowledge sharing and learning. It argues that learning is a capability of both, the social and the technical subsystem within a given system. Each subsystem has to convey its learning to the other subsystem to improve overall system performance. The other subsystem in turn has to allow for, and reflect the learning of the first subsystem. Thus, implementing successful Knowledge Management requires joint development of the social and the technical aspects. This framework is applied to two case studies representing the two paradigms of Knowledge Management. The paper explains the shortcomings in both cases relative to the socio-technical framework. It concludes that while both approaches have specific benefits, an integrated approach to a knowledge-rich business environment will eventually produce a better understanding of the ways knowledge is exchanged and organisational learning can be promoted.

Keywords: knowledge management, learning organisation, learning culture, socio-technical system theory

1 Introduction

For engineering service providers to the oil and gas industry, knowledge management is of high relevance and urgency. They operate as contractors to major players employing up to several ten thousands of employees in multiple locations around the world. Further, distributed engineering does not only refer to physical separation but also to working for different clients, often in the clients' offices. The result of this distribution is referred to as "silo mentality", a sectarian culture within the same organisation. A further complication arises from the fact that the market is shrinking, fewer young staff are recruited and in general the workforce is ageing. In the foreseeable future, a lot of the knowledge of the first generation of engineers in the UK Continental Shelf will be lost at the point of retirement. However, it is not these inherent difficulties that alerted managers to devote more attention to knowledge management but the fact that their competitors who started KM activities earlier are now able to offer their services at lower cost. One informant explained that the trigger for their new approach was "an incident that involved the company loosing an international engineering project to another company". The alarming surprise was that the competitor bid for half the price without selling their performance under price.

Although the situation is specific to Northeast Scotland, the underlying issue is of general importance, especially for knowledge intensive areas such as engineering design. There is evidence that although knowledge transfer from one unit (individual, team, department) to another is important for survival and productivity, it is not easily achieved by individuals [1]. In particular, transfer is not easy if it means applying knowledge to another domain. It doesn't always work when experts aim to pass on their knowledge. In dispersed teams, it becomes even more difficult. Certain work practices, methods and sources of information were associated with individual locations despite performing similar functions, so knowledge becomes situated within sites [2]. Engineers themselves are generally aware of the problem, and they would embrace more opportunities for systematically exchanging and sharing of experiences, however, as they pointed out, finding time and resource for an activity that is not directly related to project work as such, places a burden on it [3]. The success of exchanging and sharing also depends on an open culture to talk about mistakes and ask questions. Also pushing the lessons learnt to those who might need it may turn out to contributing to the already existing information overload. A pull approach where information is only shared when requested and only documented to the degree needed can help to keep knowledge sharing relevant. Both approaches require people to be aware of potential problems and potential users that would benefit from knowledge input.

Knowledge intensive areas such as engineering design have seen a variety of approaches to manage the storing and reuse of knowledge across projects and the sharing and transfer of experience between employees. The different approaches tackle aspects of the whole process of knowledge management as shown in figure 1 below. The modelling and acquisition of knowledge is an indispensable feature of Knowledge Management. The engineering companies in the examples above are concerned about the reuse of knowledge, which has gained importance only recently. Knowledge maintenance – ensuring that knowledge is not only available but also updated regularly – is addressed rarely [4].

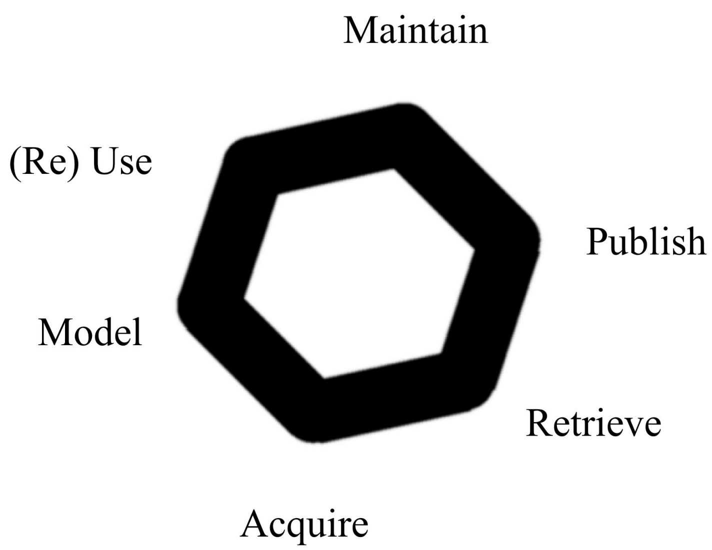


Figure 1. The process of Knowledge Management
The six basic tasks in the process of knowledge management are to capture and organise knowledge (acquire, model), to store and retrieve it (retrieve), to keep it up to date (maintain), to disseminate it (publish) and to reuse it in different contexts (reuse). [5].

The early Knowledge Management initiatives were mainly technology driven but failed to capture people's tacit knowledge. So the current second wave of Knowledge Management is directed at behaviour and culture. This approach relies strongly on the concept of Communities of Practice, originally derived from anthropological studies of how communities share and pass on expertise [5]. A community of practice is an informal network of practitioners who share knowledge and experience and address recurring sets of problems together. By participating in a "communal memory", the individual can do their job without having to remember everything themselves. When the concept was introduced, it was intended as a description of already existing organisational practice. Turning it into a management approach to improve knowledge management, however, meant that the people had to be encouraged to participate in what was intended to be voluntary.

Acknowledging the potential of a Communities of Practice approach does not mean that technology no longer plays an important role. In distributed communities, their documents and means of communication have to be available across distances and time zones, rarely involving face-to-face contact. In the oil and gas industry, Shell was among the early adopters of this approach in 1997 [6]. They implemented learning communities to compensate for the lack of disciplinary expertise building in their matrix organisation. Each community was responsible for their won knowledge base, supported by a central infrastructure team that provides the respective technical tools. Schlumberger followed with a combination of Communities of Practice and AI [7]. In fact current research into knowledge technologies suggests using structured, technical approaches to identify potential members of workplace Communities of Practice by crawling documents in a corporate repository and other recommender systems based on user profiling [8].

In this paper we propose a socio-technical framework for knowledge sharing and learning in distributed engineering situations. We then report the findings of two case studies. These case studies investigated different approaches to Knowledge Management and learning within two engineering service providers in the oil and gas industry. We relate the findings of these case studies to the socio-technical framework. In conclusion the paper argues for an integration of social and technological drivers to unlock the potential of knowledge sharing and learning.

2 Socio-technical Framework for Knowledge Management

The theory of socio-technical systems conceptualises organisations as composed of two distinct subsystems: the technical subsystem and the social subsystem [9]. The two subsystems differ in many ways. The social subsystem contains all human elements – i.e. the people, their attitudes, values, norms, histories and competencies. The technical subsystem represents human artefacts such as physical structures, buildings and other pieces of technology, but also policies, strategies and procedures.

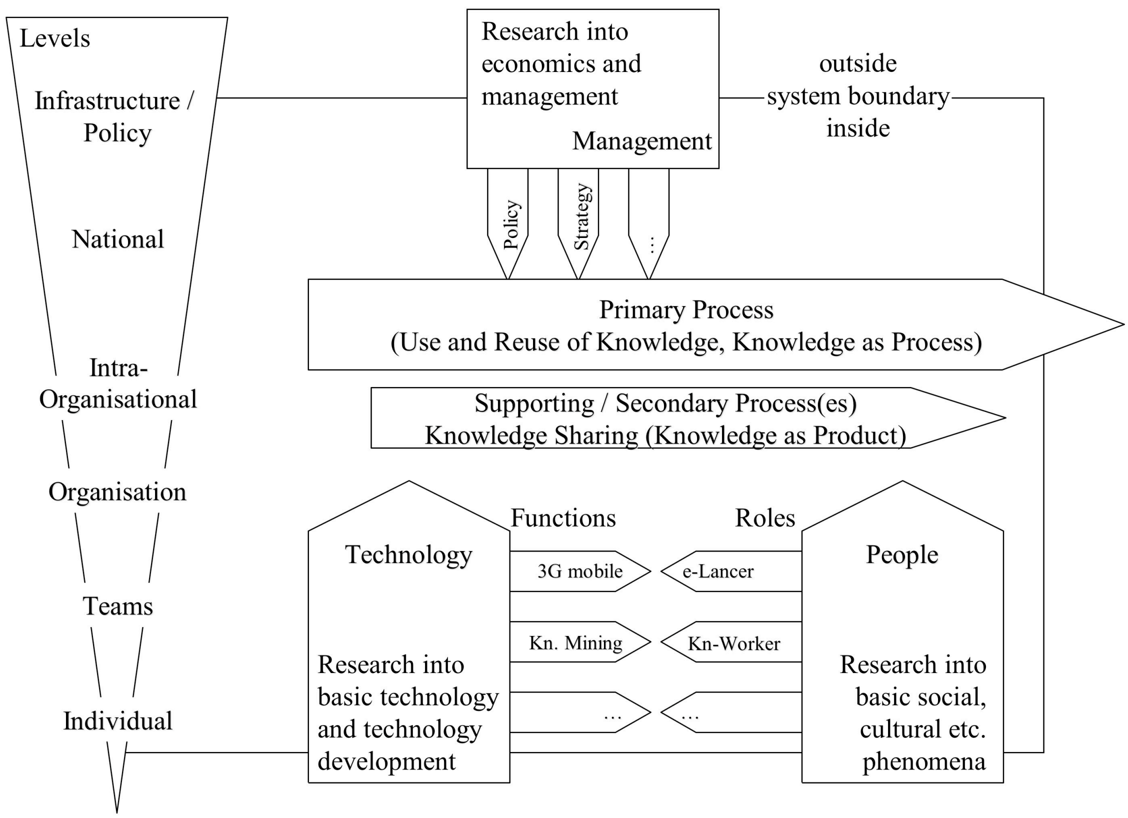
The two subsystems are understood to be in multiple interactions: They interact to fulfil the purpose the system is built for – they make the primary process of the system happen. The primary processes rely on support (or secondary) processes that make sure the primary process can take place. A management process governs the socio-technical system and steers it to achieve its goals. The social and the technical subsystems are linked by the formal and informal organisation of the system.

The members of the social subsystem fill different roles, whereas the technical subsystem provides the necessary functions. This, in fact, is the most important and probably the most complex distinction between the social and the technical subsystem. Unfortunately, some theorists (e.g. [10, 11, 12]) and many popular publications totally ignore this dimension and consequently reduce socio-technical systems design to a mere workforce participation exercise.

The theory of socio-technical systems can be and has been applied to a wide range of sites: the primary work system, the whole organisation, or even on the macro-social domain.

Within the characteristics of socio-technical systems theory, knowledge sharing and learning can easily be identified. While knowledge itself is applied to the primary process, we propose to conceptualise knowledge sharing as one particular set of support processes. Knowledge sharing can and will happen within the social subsystem, between the social and the technical subsystem, and within the technical subsystem.

Learning is equally important for a socio-technical system to adapt to changing circumstances, but it is not immediately directed toward supporting the primary process. We therefore understand learning as a capability of the socio-technical system – hence the term “learning organisation” – or of each the social and the technical subsystem. Thus, learning is performed by these subsystems, which eventually affects the roles of the social subsystem and the functions of the technical subsystem.



(c) Peter Troxler, University of Aberdeen, Research Centre in Knowledge Technologies

Figure 2. Socio-technical framework for knowledge management

To establish knowledge management and organisational learning following a socio-technical design strategy is faced with a threefold challenge – (1) to promote learning of the social subsystem (human learning); (2) to implement learning of the technical subsystem (machine learning); (3) and to integrate the two learning mechanisms into a mutually beneficial learning framework (organisational learning).

In addition to the already discussed concept of Communities of Practice, approaches directed at the social dimension of knowledge management include knowledge transfer and knowledge sharing. To promote these concepts and approaches, classical instruments of human resources management will be used, such as personnel movement, training, communication, interaction with suppliers and customers, or observation. The motives for collaboration in research and development range from access to special equipment and skills, efficient use of labour, to the need for stimulation or cross-fertilisation to surmount intellectual isolation.

Case studies of knowledge management found explicit reward schemes such as economics incentives, access to information and career advancement, but also soft rewards such as enhanced reputation and personal reputation. However, the critical success factor for knowledge exchange is not a set of extrinsic rewards since its effect tends to wear off quickly [13]. An environment conductive of exchange is needed at organisational level. Characteristic features of such an environment are to make knowledge sharing an explicit responsibility, to encourage experimentation, to value contribution regardless of rank, to promote communities, and to equip them with appropriate information and communication technology [14].

There are a number of technical aspects to human knowledge sharing and learning. Firstly, human learning can be supported by technology, e.g. computer-based training, distance learning, e-learning facilities, etc. Secondly, as human learning often is based on the exchange of knowledge and experience, technology that supports this exchange can facilitate learning. Thirdly, since human learning has the potential to change the roles of the social subsystem, the corresponding functions of the technical subsystem need to allow for and reflect these changes. However, a not uncommon misconception of many technology-driven initiatives is to implement technical solutions without providing the social subsystem with the necessary facilitation of and resources for learning.

Machine learning is a rapidly evolving field, driven by research and by new application needs. It includes knowledge acquisition (KA), case-based reasoning (CBR) and various types of machine learning as e.g. data mining, knowledge discovery in databases, or agent learning. Research seems to strive towards two kinds of systems: general-purpose systems that can be easily adapted to a wide range of applications (horizontal systems), and single-purpose systems that specialise for one particular application (vertical systems).

However powerful these systems eventually will be, socio-technical knowledge management will require them to interface with the social subsystem. This means not only providing effective visualisation techniques, addressing usability issues and prove usefulness in action, but machine learning systems have to provide comprehensive explanatory facilities to both lay users and experts whenever so requested. Further the above caveat applies to the implementation and use of sophisticated machine learning systems – user uptake is unlikely if the necessary facilitation and resources are not provided.

Organisational learning eventually arises from the beneficial combination and mutual interdependence of human and machine learning. To achieve this it is essential to make learning processes and their effects of one subsystem transparent to the other subsystem. Organisational learning releases the potential of both subsystems to improve overall system performance.

3 Case 1: Knowledge Technologies in Engineering

The first case study was set in a company that provides engineering services involving a specialized set of skills from mechanical engineering, geology, physics, and other disciplines. Because the field is relatively new, the community of skilled engineers is small, and those within the organisation are dispersed worldwide.

The company developed a multifaceted, technology-driven Knowledge Management approach. Its Knowledge Management system is composed of a rule-based expert system and three knowledge bases that are linked together – a set of performance guidelines, an online training system, and a repository of lessons learnt. The repository was built using a semantic knowledge engineering approach and later ported to the company's database driven intranet. We therefore consider these three systems knowledge storage and retrieval systems rather than knowledge-based systems, since they are task-neutral in order not to bias the form and content of the knowledge toward a particular future usage. Thus, actions are entirely left to humans, and the systems do not advise per se on any action the users should take. However, they are designed to provide easy access to the most valuable knowledge to all engineers, and linkage between engineering-related knowledge and other knowledge from the projects in which it was created.

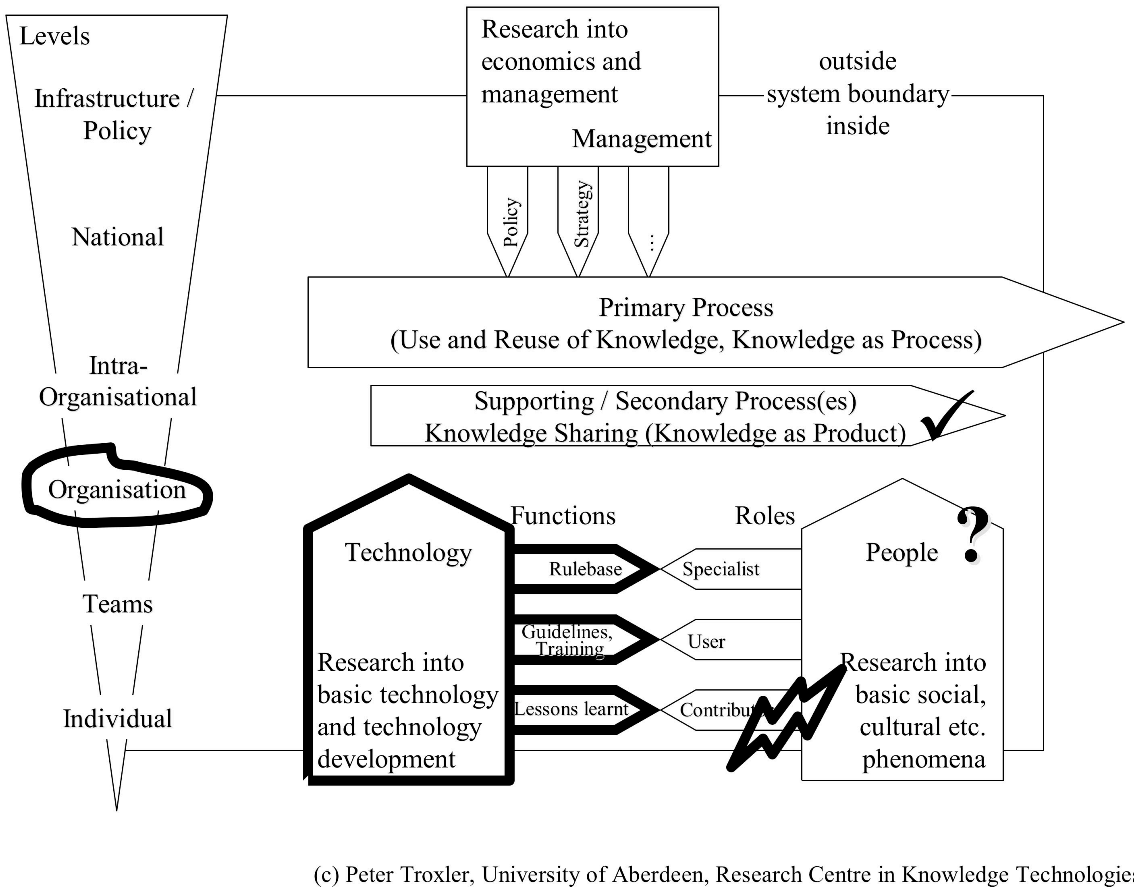


Figure 3. Knowledge Technologies in Engineering – This multi-faceted, technology-driven approach to Knowledge Management achieves sharing of knowledge but encounters problems with people not being able to contribute to the system as planned initially.

The case study investigated the use of these knowledge-based systems [15]. It showed that the systems failed to unfold their full potential (see also figure 3). Not surprisingly, performance guidelines were seen as most helpful but seldom used. Learners hoping for (human) feedback on their assignments from the online training system were disappointed by the slow response of the tutors. The introductory training did not enable users to report new cases without central support that was not available due to lacking resources. However, the company reported easy access to and successful re-use of lessons learnt across geographical areas. The case study shows that, for successful implementation, the whole socio-technical system needs to be considered at the time designing a software solution, for both phases, implementation and use. Learning did only take place slowly because sufficient resources were not allocated. However, the company could benefit from shared knowledge through the use of this system.

4 Case 2: Establishing Practices to Share Knowledge

The second case study was based in another engineering contractor company. This company focused on the implementation of Communities of Practices. Initiated by senior management in the Aberdeen base as a response to outside challenge, it builds on experience from other subsidiaries of the company. Previously dominated by information management, the new approach embraces "people to solutions" as well as "people to people" paradigms. New communities are initiated and supported by central support staff.

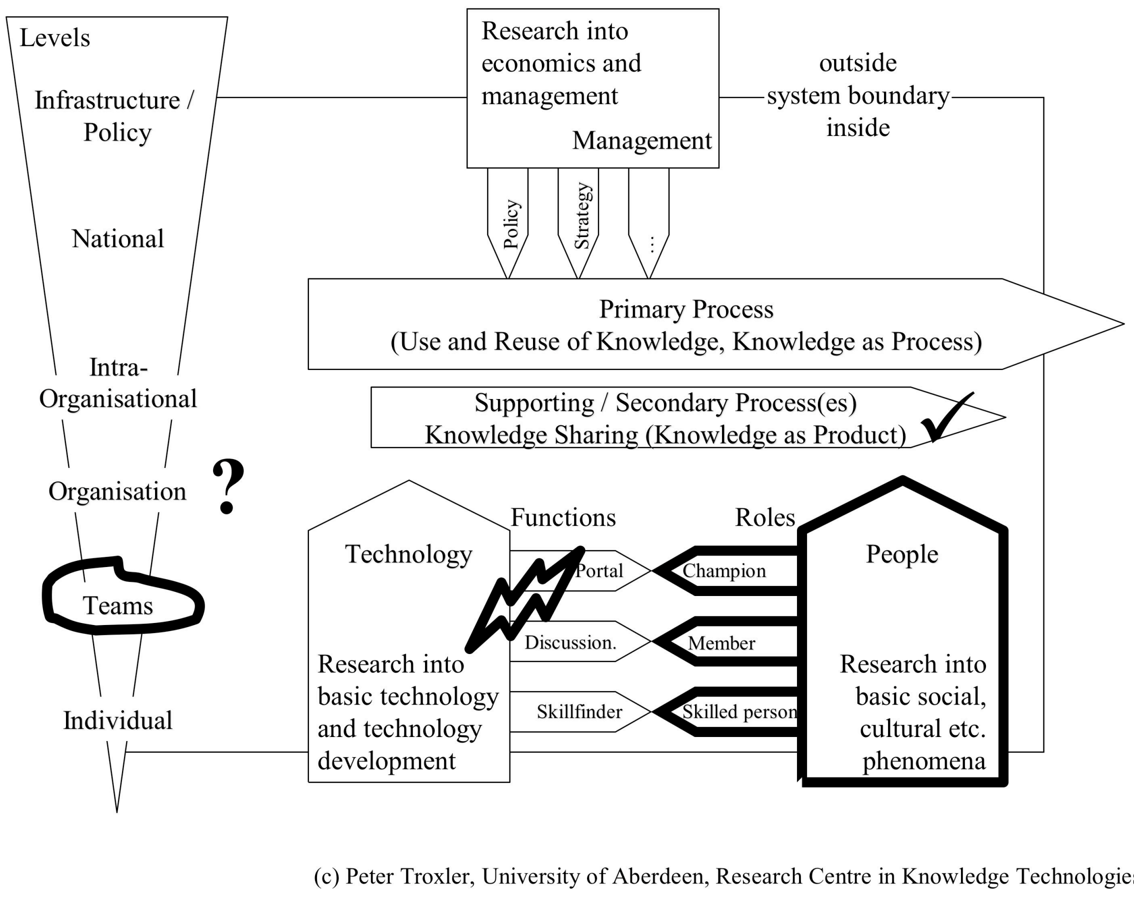


Figure 4. Establishing Practice to Share Knowledge – this community-driven approach supported by portal technology achieves knowledge sharing but encounters problems with technology and the transfer from teams to the organisation as a whole.

The number of communities quickly rose within half a year to currently 23, with topics ranging form electrical engineering to human resources, performance measurement and new graduates. The central piece of communication technology is a web portal, which includes a “skill-finder” database, a tool for threaded discussions, and any documents and tools or gadgets the communities choose to have on their portal. The intention is to replace peer-to-peer email habits with one central communication hub for a range of tasks.

Each community has a champion who promotes it and facilitates the internal discussion. Champions receive a half-day training course, which provides background understanding into Communities of Practice and stages of their development, an update of the technological features of the web portal and a brief introduction to facilitation skills. Employees are encouraged to join communities as they wish; all are open to anyone with access to the company intranet. Individuals determine the content of their skill profile and update it themselves.

We carried out semi-structured interviews with eleven of the 23 champions and issued a web-based questionnaire to hundred members (89 returned) and hundred non-members of communities (26 returned) [16]. The results can be seen as typical for the early stage of implementing Communities of Practice. In the interviews, the champions reported a healthy mixture of users but a slow take-up of the idea of communities, and a number of usability issues of the web portal. Also, some voiced concerns over the long-term management support such as "other initiatives have fallen due to funding being withdrawn" or problems of "getting my boss interested". The most active communities were those that already existed as professional groups with established social structures and regular meetings, and company-wide initiatives, which utilised the portal as a new communication channel. To our surprise, most interviewees perceived the rationale for Communities of Practice and the current benefits as mainly local. The training day and the experience of using the portal began to raise awareness for the benefit of breaking down geographical boundaries to develop communities in a global context.

The questionnaire data showed that 83.2 % of the respondents saw Knowledge Management as a priority and the majority was reasonably satisfied with how problems of knowledge transfer were addressed. However, 39.3 % felt it could be improved. The portal technology was evaluated as fit for use but employees felt there was too much focus on virtual meetings and not a strong enough vision of the future. Most participants showed an acceptable understanding of Knowledge Management, mainly centred on sharing of knowledge; there was no statistical difference between members and non-members. We did find statistically significant differences for the expected duration and the integration of Communities of Practice into the culture of the company: Members were more positive towards the integration into the culture, and expected Communities of Practice to last for five to ten years.

5 Conclusions

The two case studies found different approaches that could be described as: (1) the use of (abstract) semantic conceptualisations of knowledge (ontologies), and (2) the use of (concrete) experiences. Abstract conceptualisations are explicit and systematic. They work very well with information/knowledge technology. Yet they may not be suitable for all individual learning styles, and they risk lacking immediate action orientation. Sharing of experiences is much more action orientated. It is well suited as the core of a behaviour-oriented knowledge management strategy. Transferring experience to another context though is difficult and most probably based on intuition rather than systematic reasoning.

Further efforts are needed to tackle the problems of knowledge transfer. Yet we would strongly recommend not adopting simplistic solutions too quickly, whether they mimic social behaviour using technological means, or they use technology as mere communication channels and easily accessible storage devices. Rather than a compromise, we aim for an integration of social and technological drivers. Such a joint optimisation approach to knowledge management utilises technological options for efficient ways of knowledge transfer across boundaries of time and space, but considers them from the point of view how to best develop a learning culture across organisations. This socio-technical approach to a knowledge-rich business environment will eventually produce a better understanding of the ways knowledge, especially lessons learnt, are transferred between people and teams at different times and locations, even if the context differs in terms of situations, experience, education, culture, and technical equipment.

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