

The Role of Technology Support in Knowledge Management Evolution in Innovative Companies

Conference paper

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Abstract: *Technology is an essential part of most knowledge management (KM) initiatives, and the researchers have been both praising and criticising it for almost three decades. In this paper we take a more balanced view of the role of technology in KM and suggest that the impact of technology and the reliance on changes depend on the phase of KM evolution in a company (company's experience with KM practices). In particular, we examined different types of knowledge management systems (KMS) in the context of innovative companies from the energy sector and found that at the beginning companies are quite reliant on document repositories that help them to manage explicit knowledge. When they start paying more attention to knowledge sharing practices, the role of technology shifts to the periphery where wikis were found to be the most useful tool.*

Keywords: knowledge management, knowledge management systems, innovation management.

Introduction

Knowledge Management (KM) emerged from the field of artificial intelligence (Liebowitz, 2001; Wiig, 1997), and non-surprisingly it was focused on technology later referred to as KMS. The perception of the importance of technology in KM varies in the literature (Alavi and Leidner, 2001; Sher and Lee, 2004) and was changing with time as the technological solutions evolved. In the recent years the discussions shifted towards examining the behaviour of online communities and virtual teams enabled through online platforms (Alsharo et al., 2017; Gilson et al., 2015), while the questions of adapting knowledge management systems (KMS) in companies moved increasingly in the domain of consulting companies. The aim of this paper is to clarify the role of technology in the current state of KM practices in technology intensive innovative companies. In a way this paper revisits the review of Alavi and Leidner (2001) that attracted researchers' attention to this topic at the turn of the Millennium, and provides an update on the position of KMS in innovative companies in the case of the energy sector.

KMS refer to the class of Information Systems (IS) for managing organisational knowledge (Alavi and Leidner, 2001). Though not all KM initiatives involve integration of KMS, the majority of the projects are built around the implementation of new technologies for a number of reasons. The projects that involve a tangible component (such as an IS) are easier to justify and advocate, and therefore to have budget allocated, partially because the functions of an IS are easier to understand than the soft aspect, like cultural and organisational change (Davenport and Prusak, 1998; Loebbecke and Myers, 2017; Myers, 1995). Apart from that, various classes of IS (e.g. ERP systems) have been supporting knowledge workers and have substantially improved the performance of companies in the past. This success led to overreliance on technology and belief in its magic properties and ability to solve any problem (Davenport, 2005).

The issues listed above do not imply that technology is of no use in KM, on the contrary, it can be of great help, but overemphasising technology neglects other important aspects of the initiative. Additionally, the abundance of different types of KMS and the lack of understanding of what they are, might contribute to the high failure rate of KM projects. 60% of the global corporations have spent \$4.8 billion on knowledge management initiatives and KMS implementation (Babcock, 2004), of which only 26% reached implementation stage (KPMG, 1998), and most of them failed at the end.

These issues along with the findings in this study indicate that we still do not have a clear picture of what constitutes a good KMS. These issues are rooted in a techno-centric approach to KM, and were later counterbalanced with focus on the people's practices and behaviour coming from organisational studies. This study looks through a third lens – a process view, which was originally developed by the distinguished KM scholars Prusak, Davenport and McDermott, and which attempts to combine the two traditions and to take a balanced view of KMS, and can also be referred to as socio-technical perspective (Wan et al., 2017).

This paper constitutes the second part of the research project (Shpakova et al., 2017), in which KM in innovative companies is presented as an evolution path – a roadmap of KM. The study aimed at understanding the needs that KM practices correspond to in innovative companies and how they change with time. The resulting model was derived from a multiple case study of innovative companies from the energy sector sharing similar organisational characteristics, but having a different degree of success in engaging in KM practices. The model consists of 3 phases: managing explicit knowledge, knowledge sharing and creating new knowledge. The first phase corresponds to the need to organise articulated knowledge and establish processes for further management of this knowledge by formalising them and introducing standards of practices. The second phase incorporates different forms of knowledge sharing and learning, and includes KM practices that support its informal and organic nature. And finally, the third phase focuses on the creation of new knowledge and proves that KM and innovation management are intertwined and inseparable from each other. This paper suggests the types of technology that were found suitable in each phase of the model and discusses the changes in the role of technology as KM practices evolve.

The paper is structured as follows: it starts with the literature review that indicates existing literature gaps, justifies the need for this study and prepares a theoretical basis for the study. Then it describes a methodological approach that was employed in this study. Following that, it presents the results of the study and clarifies the role of technology in KM in the context of the model of KM evolution. And finally it discusses the results and indicates possible directions for further research.

KMS in the literature

A lot of the KM initiatives aim to use KMS for capturing organisational knowledge in a form of best practice (Goodman and Darr, 1998; Voelpel et al., 2005), and these attempts are

sometimes successful, if the practices are indeed applied and reused. For instance, Xerox estimated a payoff of \$1.2 billion from applying best practices in key areas (O'Dell and Grayson, 1998). Other companies focus on mistakes. For example, Honda keeps a record of unsuccessful development ideas, recognising that they might have high potential in the future (Davenport and Prusak, 1998), while ConocoPhillips gives a special award for sharing painful lessons learnt (O'Dell and Huber, 2011).

The above examples aim at codifying knowledge that can be articulated, and this approach remains at the core of technology-centred KM initiatives. The codification driven KM strategy assigns three purposes to KMS: (1) coding and sharing best practices, (2) creating corporate knowledge directories, and (3) creating knowledge networks (O'Dell and Grayson, 1998; O'Dell and Huber, 2011). This view suggests that knowledge can be codified and mapped, and networks can be facilitated with technology.

Codified knowledge in a form of best practices is usually supported by knowledge repositories, though with limited success. In particular, best practices are highly contextual and difficult to articulate in order to fit into the rigid standardised templates (Goodman and Darr, 1998), which might affect the quality. On the one hand, moderating the quality might lead to polarised results: too rigid rules discourage participants (Goodman and Darr, 1998), but on the other hand, too much freedom turns the repositories into junk yards (Brown and Duguid, 2000). The other aspect of quality is related to the ability to keep such repositories up to date, an issue that is also relevant to the second purpose of KMS listed above, of creating knowledge directories or knowledge mapping.

Some companies choose to map knowledge centrally with little or no use of technologies in a form of a map (O'Dell and Grayson, 1998). Others prefer a decentralised approach through yellow pages or profile libraries of employees (Andreu and Ciborra, 1996). With the emergence and increasing popularity of social media, commercial Facebook-like tools (corporate social networks) became widely adopted and replaced profile libraries. They allowed a more informal emergence of knowledge maps (Lank et al., 2008), but still relied on the efforts of knowledge workers to keep them up to date and relevant. They can also become a catalyst by creating an environment that encourages and eases the development of knowledge networks (O'Dell and Grayson, 1998; Wenger et al., 2009), the third objective of KMS.

The above examples address all three purposes of technology in KM. But they also demonstrate the limitations of such view on KMS, because they do not include a variety of other potential

applications of KMS, such as supporting collaboration between knowledge workers, which Web 2.0 tools have been praised for. A number of researchers took a different approach and instead of trying to identify the overall purpose of technology in KM they suggested the situations in which different types of KMS would be appropriate. We identified three such frameworks in the literature: those of Davenport (2005) and McIver et al. (2013), which depart from different types of knowledge workers, and the framework of Wenger et al. (2009). The third framework is focused on the communities of practice and therefore does not cover all the areas of KM, but is still worth reviewing, because it contains a high level of detail.

KMS frameworks

Davenport (2005) based KMS recommendations on the nature of knowledge work: the need in collaboration and the level of complexity. The first dimension distinguishes two levels of technology support: individual and organisational. On the individual level technology, such as emails and chats, aims to increase the productivity of the workers, whereas technology on the organisational level supports group work. Then the types of technology are further classified based on the level of complexity of the work, where the technology can either support routine tasks or help with insights to make a better judgement (Figure 1).

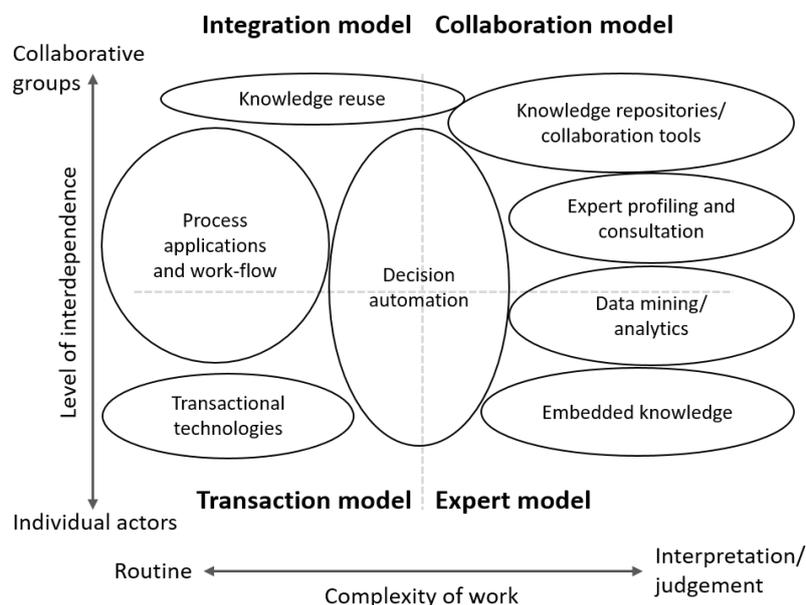


Figure 1. Organisational technologies for different types of knowledge work. Source: (Davenport, 2005).

In particular, the transactional workers (individual actors involved in routine work) require technologies that simplify and support their routines, such as giving relevant information on time in a call centre. Their work does not depend on the regular collaboration with their

colleagues, although they could still benefit from it. As the work becomes more collaborative, it needs to be supported with different technologies, such as project management tools or product design reuse for lower-level engineering. These tools allow them to mainly coordinate the collectively created output. As the work grows in complexity, at the expert level it can be supported with knowledge-based systems, e.g. patient diagnostics support, and analytical applications, such as data mining. And finally, if the work of experts also requires collaboration, articulated knowledge becomes more difficult to be reused compared with integration model workers, because their work is increasingly dependent on the context. Instead knowledge workers need tools that will help them to connect with each other and receive a timely input from each other.

Similarly, McIver et al. (2013) based KMS classification on the nature of knowledge work, but they used the dimensions of learnability (how much time is required to learn it) and tacitness (to what extent it can be articulated) of knowledge in practice, and discussed the knowing processes that are associated with each type of work. The types of technologies were then connected to the knowing processes, where three of the processes – learning, assimilation and application – were not supported with any technology. The other processes were supported with the categories similar to that of Davenport (Figure 2).

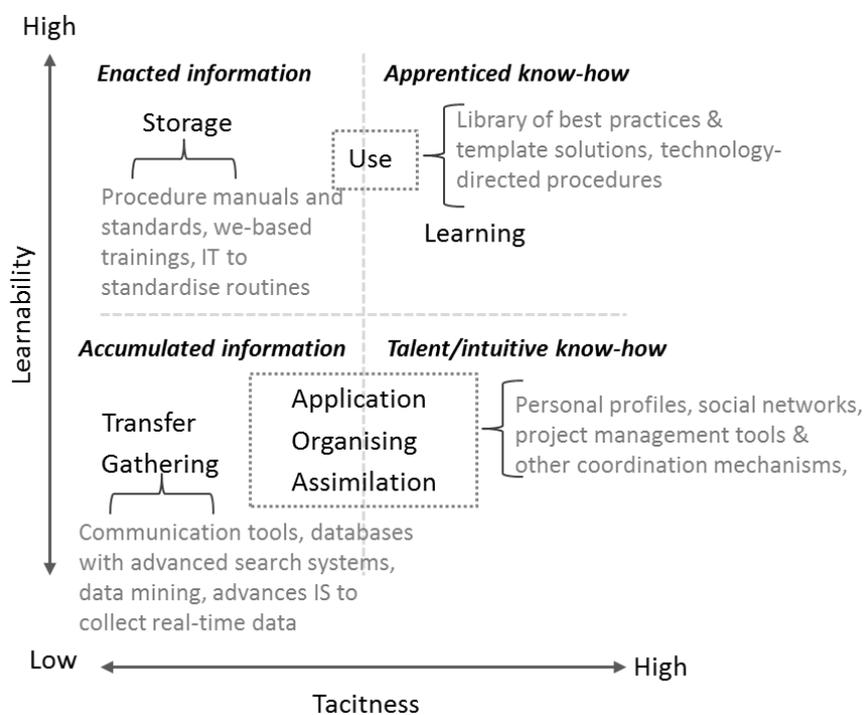


Figure 2. Knowledge in practice for organisational work and related processes. Adapted from McIver et al. (2013)

What this framework also shows is that with the increased level of tacitness of acquired skills it is increasingly difficult to find a type of technology that would support this work, which was noted before. For example, in the groups with higher learnability the library of best practices is considered useful. But for the apprenticed know-how group the context around the best practice becomes increasingly important and more difficult to share, so simply providing a document repository is not sufficient. In this light both frameworks complement each other and indicate the limitations of the technology.

The framework of Wenger et al. (2009) presents a classification of the tools that are useful for communities (Figure 3). The researchers use three dimensions to categorise the technology: individual vs. group activities (similar to Davenport’s framework), the synchronous vs. asynchronous working mode, and the focus on the discussion with other participants vs. the creation of new contents.

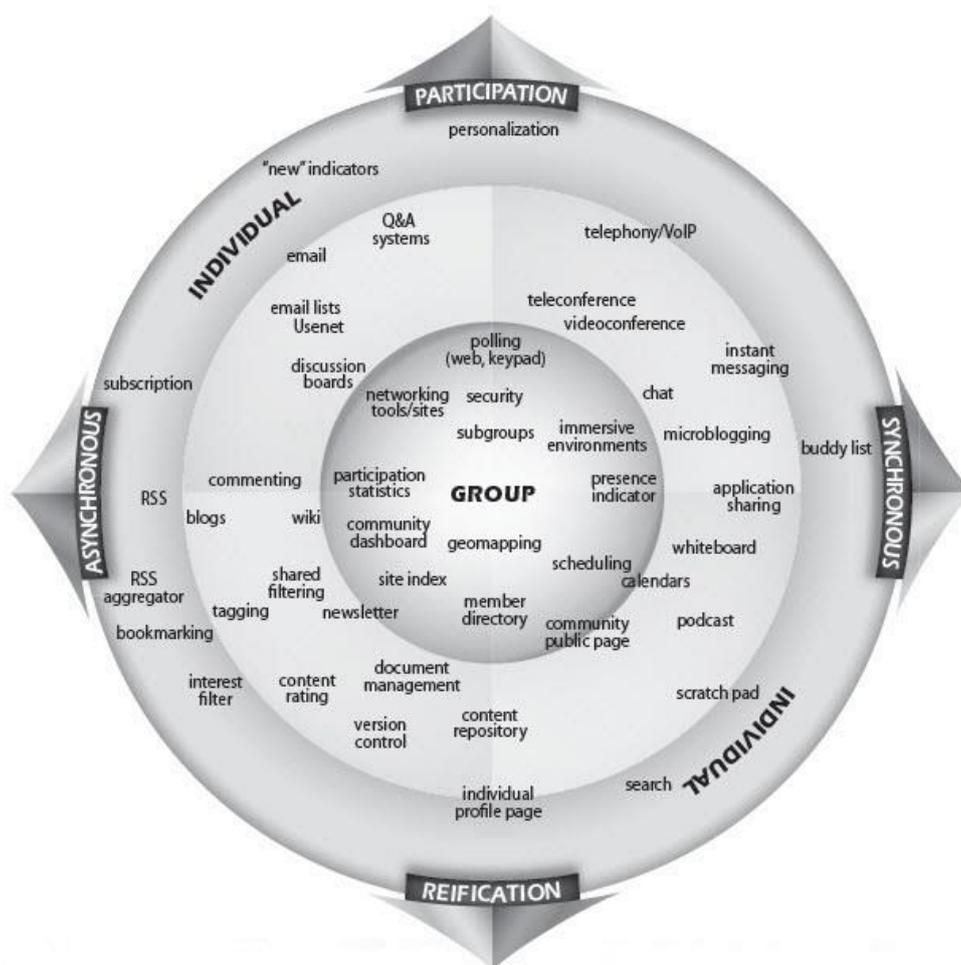


Figure 3. The tools landscape. Source: (Wenger et al., 2009).

In this framework the authors classify tools, such as blogs and wikis, and their functions, such as tagging or search, which can be used only when coupled with one of the tools. From the concentration of tools in certain areas one can see that most tools are developed for group work, and even individual tools, such as interest filters, assume indirect involvement of others (e.g. in creating contents). This classification is important because it provides a more detailed view of KMS and allows to be more specific when investigating the use of technology in the organisational environment.

The first two frameworks were developed using different approaches to classifying knowledge workers, and the similarities between them validate both frameworks in a certain way. However, the categories that the authors provide blur the boundaries of KMS with other IS. Therefore, it is reasonable to ask whether KMS can refer to any system that supports knowledge work. For instance, decision automation and data mining tools are used in knowledge-intense types of works, but they also tend to be industry or company specific, and therefore are difficult to apply in a different context. Therefore, studying them together with other types of KMS might broaden the scope too much. Similarly, embedded knowledge systems (e.g. expert systems) contain the body of organisational knowledge, and therefore, according to the definition of KMS, should be categorised as one (Alavi and Leidner, 2001), but they are unique to each company. Due to their specific nature these systems might not face the same implementation and motivation issues, since their benefits are more obvious and the effects are more distinct and transparent. Moreover, these categories of systems might be understood completely differently by different practitioners. Because of these issues we might find that the systems that researchers classify as KMS might not be considered as such by practitioners.

The literature review demonstrated that there seems to be no clear understanding of the purpose of technology in the KM literature, or it might be outdated. However, we identified suggestions regarding the categories of KMS that might be more appropriate in various organisational settings, and these categories can be used to examine the application of KMS in innovative companies in more detail.

Davenport's model (2005) defines the following categories of KMS: knowledge repositories, collaboration tools, business analytics, knowledge-based systems, process and work-flow applications, expert profiling, or more recently corporate social networks, and transactional technologies. The last group is very work-specific and cannot possibly be covered within this paper, and therefore it is not reviewed. McIver et al. (2013) suggest the same tools, some of

which have different names, for example, coordination tools which serve the purpose of workflow application. The authors also emphasise the importance of search engines. And finally, Wenger et al. (2009) describe Web 2.0 tools along with collaboration tools, content repository, search engine and numerous features of these tools. To summarise, KMS are split in the following categories: knowledge repositories, collaboration tools, coordination tools, Web 2.0 tools (which include forums, blogs, wikis, portals, podcasts and corporate social networks), knowledge-based systems, and analytical tools. These are the categories of KMS that were identified as a starting point in the empirical part of this research. The next section discusses the methodological approach to conducting the empirical part of the research in more detail.

Methodological approach

This research was designed as a multiple case study (Yin, 2014), because it allowed to observe KM practices and types of technology in use in companies with different level of engagement in KM, and thus grasp its complexity (Gummesson, 2006). Analysing those differences and understanding whether they construct a pattern led to the development of a KM model that shows a change of the focus on certain KM practices in time. And with the evolution of KM its practices also changes the need in types of KMS to support them.

The study was focused on innovative companies, because innovative activities (e.g. R&D) are considered a more knowledge intense area, where practitioners find it more difficult to improve KM practices (Voelpel et al., 2005). This issue is particularly relevant in relation to the use of technology in KM, whereby highly contextual knowledge in R&D might lose its complexity and contextual value to a greater extent when supported with KMS (Doz and Wilson, 2012). On the other hand achieving improvements and understanding the role of KMS in innovative companies might be more rewarding and better visible. The energy sector was chosen as a representative industry of innovative companies, because ambitious environmental goals that it is set to achieve drive it to seek innovative solutions. And in order to ensure the focus on innovation, the participants were chosen from the practitioners who are involved in innovative activities, such as research and development, on a day to day basis.

Data collection

In order to understand the role of technology in KM this research adopted a multiple case study analysis. Case studies can employ a variety of methods to gather empirical material (Eisenhardt, 1989; Yin, 2014), but interviews remain the most widespread one (Crouch and

McKenzie, 2006) being flexible enough to adjust to various research needs. The flexibility of the design allows researcher to find a needed balance between the contextual richness and the degree of structuring of the empirical material (Saunders et al., 2011). Therefore this method of gathering data seemed appropriate for this research, and was designed as semi-structured interviews which allowed us to gather deep insights and make them comparable at the same time (Chapman, 2001).

The sample size in qualitative research is expected to be smaller than a size of a dataset for statistical analysis due to it being more labour-intensive (Crouch and McKenzie, 2006). However, the suggested number of interviews to ensure robust theoretical contribution varies from 15-20 (Marshall et al., 2013) to 30-50 (Morse, 1994). The recommended number of organisational studies is in the range of 30-50 (Saunders and Townsend, 2016) with 3-5 interviews per case in a multiple case study (Creswell, 2013). Since this recommendation is the closest to the studied context, it implies that we require 6-10 companies with around 5 interviews in each. With this suggestion in mind we conducted 32 interviews in 6 companies.

In the introduction we have described the model of KM that was developed as the first part of this study – the organic roadmap of KM. The model and the technology aspect of it were developed based on 32 interviews with innovation practitioners from 6 companies (Table 1), which lasted from 30 to 70 minutes each. During the interviews the participants were asked to share their experiences of using different types of KMS and to give their opinion about their advantages and disadvantages, after having discussed various KM practices they are involved in and various issues associated with them.

Table 1. List of companies interviewed.

Company name	Company type	Size	N of interviews
SSE Power Distribution	Distribution Network Provider	500	6
SgurrEnergy	Engineering Consultancy	500	5
SP Energy Networks	Distribution Network Provider	400	5
Weir Group	Engineering Consultancy	14 000	6
Caltec	Engineering Design	18 as part of 20 000 emp. Company	4
Silver Spring Networks	Engineering Design	600	6

In the discussion of the findings the companies are referred to as 1 to 6 according to the perceived level of engagement and progress with KM, but these numbers do not correspond to the order of the companies in the table above. Below is the description of their level of involvement in innovative activities and KM practices.

Companies 1 and 2 had engaged in little knowledge sharing, and justified it by mostly not having time for it. The scope of innovative activities was mostly fragmented and consisted of disjointed projects that were not very well connected with the rest of the business. Document management was poorly organised and some of the interviewees recognised this as the major issue. Though one of the companies had a formal KM team, it served mostly a commercial purpose – to demonstrate the novelty of projects in order to justify the funds, and learning from past experience largely depended on the consciousness of project managers.

Companies 3 and 4 had document repositories that were working reasonably well, and both of them had assigned a person to be responsible for KM, and were mostly concerned with improving knowledge sharing between engineers and project managers, and particularly lessons learnt and their impact on future work. The innovative projects were well aligned with the organisational strategy and KM was seen as one of the aspects that would help to improve their innovative performance.

Companies 5 and 6 were not concerned with the document management problems anymore, because they had well-established practices. It was possible to see quite a lot of examples of knowledge sharing, though it was not always successful, and both companies were greatly concerned with managing new ideas, having people that were responsible for ideas management. Both companies saw innovation as being at the core of their business success and regularly engaged in a systematic ideas collection. One of the companies was preparing a large scale open innovation initiative to harvest more fruitful results from their ideas collection.

Data analysis

The analysis of the interviews was conducted using two methods: Concept mapping as an extension of the SODA-style cognitive mapping technique (Eden, 1988; Pyrko and Dörfler, 2014), and Gioia's method of establishing second order themes (Gioia, 2004; Gioia et al., 2013). The first method was meant to help structuring the interviews and finding common patterns across the cases, which can then be complemented with rich in context insights from these interviews extracted with the second method. The combination of the two methods might resemble the case study approach developed by Eisenhardt (1989) based on deriving the same

insights from different methods applied to the same empirical material. However, the research design in this study is different, because the two methods are complementing rather than duplicating each other. These methods require further explanation.

Concept mapping

Concept mapping is related to a cognitive mapping technique, which draws a model of one's thinking (Eden, 1988) by linking concepts with causal relationship (Laukkanen, 1994). However, unlike cognitive mapping, concept mapping does not organise the concept hierarchically, it rather captures a state of entities and various relationship between them. The analysis was conducted with the help of a specialised software, Decision Explorer¹, and the example of a map for one company is presented on the Figure 4.

The teal colour on the map represents KM concepts and the purple one refers to the KMS. For example, this map shows that *document repositories* start being integrated in the main work activities; *forums* are actively used, but remain at the fringes of business activities. Decision Explorer also allows us to perform centrality analysis by calculating the influence of each concept on other concepts. For example, *ideas* concept seems to be well connected with other concept, but the centrality analysis does not show it as such. On the other hand, *resistance to change* does not seem to be well connected on the map, but was identified through centrality analysis among of the most influential ones.

¹ <http://www.banxia.com/dexplore/>

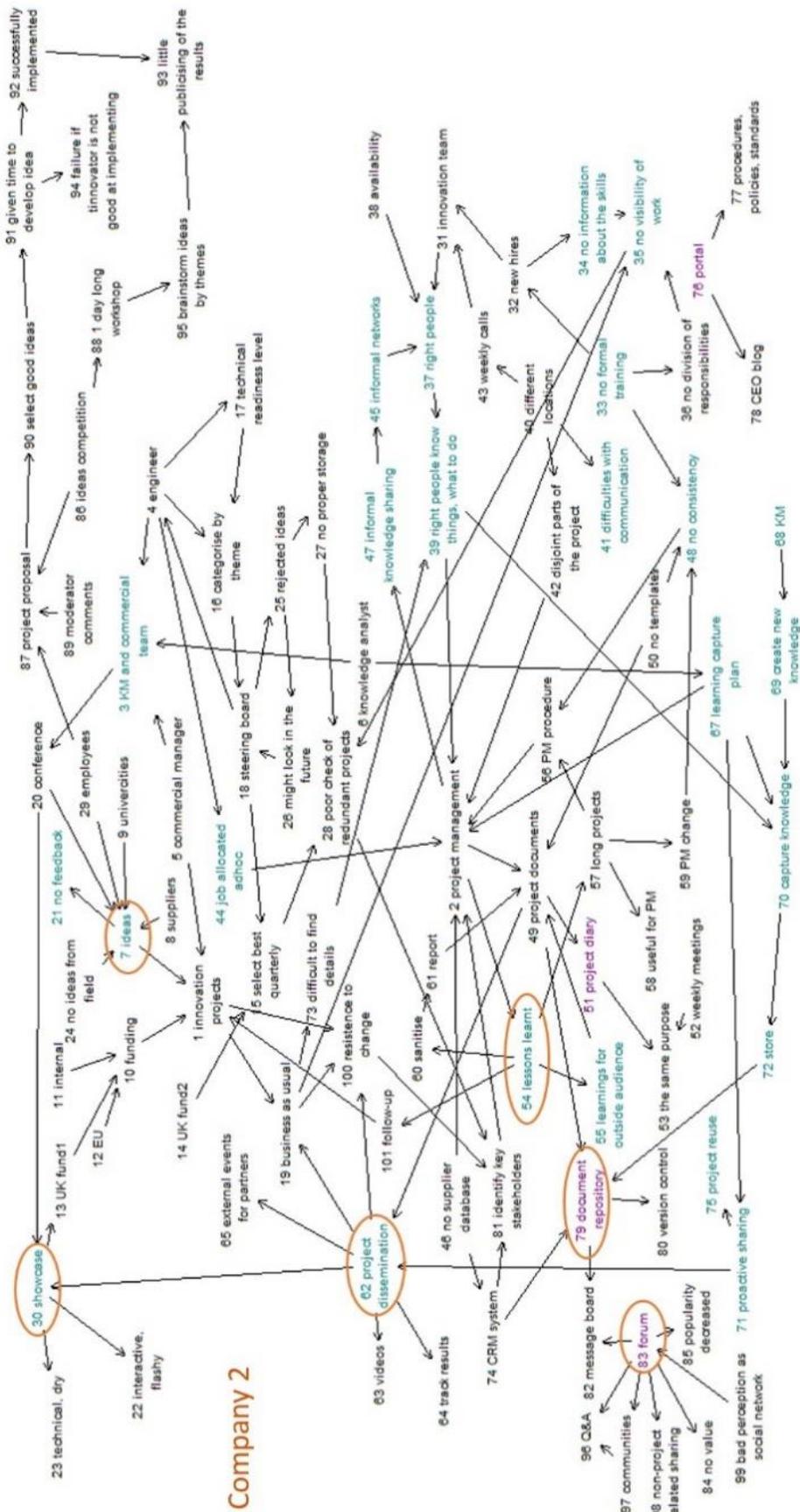


Figure 4. Concept map for Company 2.

Centrality analysis along with the analysis of concept maps allowed to build a structure of the model with key KM practices and KMS types that were identified as important at different phases. And then these practices and types of technologies were explored further through Gioia's method, enriching the model with detailed insights from repeated emerging themes.

Gioia's second order themes

Gioia's method (2004) of establishing second order themes consists of a three-level codification strategy, where on the first level common themes are identified across a data set, on the second level the identified themes are grouped into higher level second order themes, and finally, the second order themes are united in aggregated dimensions (Langley and Abdallah, 2011). The codification of all interviews' transcripts was conducted in NVivo software.

This method helps to gain a deeper understanding of each individual case and the context around it, allowing us to understand the underlying reasons behind the observed phenomenon. In particular, we might identify that a type of KMS, e.g. wikis, is successfully used in a particular company and has an impact on the working activities, which is reflected in the centrality analysis. The analysis of the interviews can reveal the purpose of wikis and the reasons behind their success, therefore contributing to the understanding of what types of KMS should be used at different phases of KM evolution and why. Thus this example demonstrates that both methods complement each other allowing us to draw a fuller picture of KM and understand the role of technology in it in innovative companies.

Findings

The centrality analysis of the interviews as a part of concept mapping has shown that in the first phase – managing explicit knowledge – document repositories play a crucial role in helping to organise explicit knowledge and make it retrievable. Starting from the second phase the role of technology shifts to the periphery of the KM initiative and rather becomes an extension of the document repository in the form of wikis, but the application of wikis and other WEB 2.0 tools extends beyond document management (Figure 5).

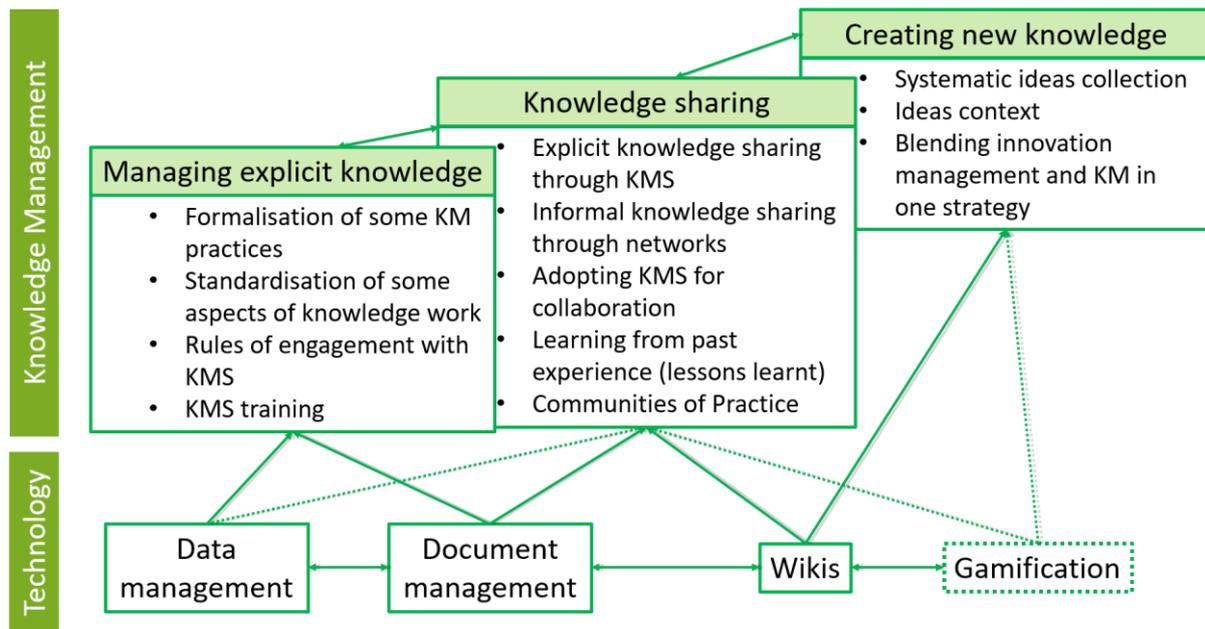


Figure 5. The organic roadmap of KM extended.

Of all the types of KMS discussed in the literature review document repositories and wikis were found to be the most helpful for practitioners, but they are not rigidly connected to only one of the phases of this model. For instance, document repositories are essential for managing explicit knowledge, but they also provide space for knowledge sharing. Similarly, wikis ease collaboration and support knowledge sharing in its various forms, but through collaboration new knowledge can be created (Velencei et al., 2009), therefore both types of KMS were located between the phases on the roadmap of KM. However, these were not the only two types of KMS found in practice, although the areas of application of the other types that were discussed in the literature review were more specific, as is shown below.

Document repository

Document repositories have been both praised (O'Leary, 1998) and criticised (Brown and Duguid, 2000; McDermott, 1999; Sveiby, 1996) in the literature. Sometimes they are assimilated with knowledge repositories (Braganza et al., 2009; Davison et al., 2013), and in essence both are referred to as an IS for storing and retrieving useful documents and records. The interviewees referred to the knowledge repositories as a place with a collection of scientific articles, methodologies, technical documentation, in other words, their purpose was not substantially different from that of document repositories. Therefore, the distinction between the two was not found necessary.

The interviews showed that documents management is the initial problem that the companies face when they come to understanding the importance of KM.

“Wikis and forums is something that we’ll do, but I think, what it is at the moment, is we really want them just to engage in the SharePoint library to upload the knowledge and learning and documentation before we start pushing other tools at them.”

Of the companies interviewed Company 1 has only started to realise the scope of the KM related problems that they were facing at work, Company 2 was in the process of implementing a document repository and saw it as their primary objective at the time, and Company 3 had a document repository in place and was trying to make it work. Other companies were less concerned with document management related issues as they already had functioning systems in place. Overall the interviewees had quite realistic expectations of a document repository and required the system for the following four reasons: the support of versioning, tracking, back up and file sharing, and less frequently for access control.

Document repositories are an important starting point in the KM journey and can be very useful as long as their limitations are understood, but their absence will hold the KM evolution back. However, installing the system alone is not sufficient. The interviewees shared problems related to information being duplicated or outdated in the system, the lack of an information management process, and poor search function support. One of the characteristics of the first phase of the KM model is the need for standardisation and formalisation of certain aspects of knowledge work, which arose in response to the issues mentioned above.

One company used wikis as an alternative to a document repository. Wikis address some of these problems, because they are more flexible, but structured enough to control the flow of contents, offer a better search function and provide collaboration support in managing the documents.

Corporate portals / Intranet

Corporate portals are less discussed in KMS literature and are mostly referred to as a single point of access (Dias, 2001) or an integration tool (Loebbecke and Myers, 2017), or a tool to promote gathering, sharing and dissemination of information (Detlor, 2000). All the companies interviewed had a corporate portal with a limited customisation potential, and in most cases it was used as an extension of document repositories for storing generic documents, such as formal policies, or HR documents, for posting high level news from the CEOs, and for providing links to other job related systems and databases. In the literature the portals are

distinguished from the ordinary corporate website by their ability to be tailored to specific user needs and therefore to filter the information displayed to the users (Benbya et al., 2004). However, in the companies interviewed this only happens on the regional or division level. Portals can become an integrating component for other KMS and play a role in disseminating information, e.g. hosting newsletters. Most of the interviewees described skimming through the news in order to be aware of major changes in the company, while the experts emphasised the importance of promoting various initiatives in the company, which can be done naturally through newsletters. However, as corporate portals are becoming more widespread and elaborate (Conroy, 2013) they may come to play more significant role – therefore this topic may be relevant for future research.

Coordination tools

Coordination tools in the context of the chosen companies are technically Project Management (PM) tools: as PM tools are used to help coordinating KMS efforts, and in use they become coordination tools. PM tools are quite widespread and software vendors offer an abundance of tools of various levels of complexity. However, only one the companies interviewed used a specialised PM tool, which also incorporated a document repository. Though the convenience of project managers might not have been the main driver behind the implementation of this system, it offers a number of advantages, such as automated project tracking for each employee and customer, and good collaboration support including the ability to attach emails to a particular task or update, which simplifies the documentation of the project progress.

Other companies used email, spreadsheets or MS Project to coordinate project progress and as a document storage system. The discussion of this type of tools reinforced the need for a systematic storage of project documents in a dedicated place which could be easily searchable and accessible in the future, the need that is addressed by document repositories. The interviewees also noted the demand for formalisation, which would create clear rules of engagement and a sense of obligation, as was discussed within the scope of document repositories as well.

One of the companies was using wikis as a project management tool. It was utilised as a collaboration and coordination tool for the team, to replace email for sending updates to interested parties about the project status, and as a document repository and a dynamic document co-creation tool, which proved to be more convenient than file sharing.

Profile library / CSN

Profile libraries have been mentioned in the literature as one of the essential components of KMS (Andreu and Ciborra, 1996), but of all the companies interviewed only one was using profile pages, which included brief description of prior experience of their employees, although they were used externally as CVs for client companies rather than internally. In all the other companies profiles were limited to an organisational contact book and the interviewees did not see the need for more detailed profiles. In their opinion profile libraries would most probably not be regularly updated, while title and a brief description of their job would not be particularly informative. For instance, in a large organisation the same title could mean a very different level of experience and depth of expertise in different countries. In a smaller company employees would rather seek a recommendation through their network.

Despite the overall scepticism towards profile libraries, one company found LinkedIn as a viable useful alternative. In their view people are most likely to update their LinkedIn profiles, and if not, then they will most probably not update their internal profile page either. Apart from that, the background information on LinkedIn provides a better insight into their past experience both within the company and outside it. LinkedIn is yet another example of using social media or Web 2.0 tools for KM purposes, being a more convenient alternative to the conventional tools.

Corporate Social Networks (CSN), which are sometimes seen as a replacement to profile libraries, were not used by any of the companies interviewed. This tool is unlikely to be useful as a stand-alone system, but it can be easily merged with any other Web 2.0 tool and serve as a complementary social layer. The reasons for that might be that CSNs were mainly praised for their speed and connectivity (O'Dell and Huber, 2011), which is relevant in highly dynamic industries, but less so in moderately dynamic ones such as the energy sector, especially in the area of product development, where larger projects can last for years, and having commitment and progress recorded is much more important.

Wikis

Wikis provide space and tools to create a collective piece of work, where the content can be edited multiple times by different users (Boulos et al., 2006). Wikis do not emphasise ownership of the posted content, and it encourages the participation of those who are afraid to be criticised or do not want to put themselves forward (Ardichvili et al., 2003). The deregulated nature of participation raises fears of lower quality of the content (Wagner and Bolloju, 2005).

However, the changes can always be traced back to an individual, which creates peer pressure, because an edit puts the editor's reputation at stake. As a result, the contents tend to be quite accurate and up to date in communities of active users; it becomes dynamic knowledge – it is recorded, but constantly updated (Lambe, 2008).

Among the companies interviewed wikis were the most adopted Web 2.0 tool for a wide range of applications, with most of the interviewees being satisfied with them. The users of wikis adopted them to record information about projects for future reference, to document best practice, lessons learnt, or issues related to the project, to conduct initial research and find documentation, to track updates by subscribing to a particular page (e.g. changes in technical requirements), to collaborate with other members of the team, to distribute training materials, or to aggregate document repository entries and summarise information about a particular topic.

Wikis were mostly praised for being flexible, easy to use and having a simple structure, allowing knowledge workers to work on the same documents and distribute information by letting people subscribe to the page of a project, whenever someone becomes interested in it. This reportedly led to a significant reduction in unwanted emails. This principle creates a knowledge pull dynamic, giving people a choice of what to follow. But ease of use and a straightforward structure were also seen as a drawback of wikis. In one company wikis were reported to be messy and contain redundant information due to the lack of rules of engagement. However, this problem can occur in other systems as well, e.g. document repositories. Apart from that wikis raised trust concerns among some interviewees precisely because they are less formal.

One of the companies share future plans to add gamification elements in wikis to allow employees to rate the posts and to give points to the contributors, which when accumulated could organically identify the experts, thus further extending the capacity and range of applications of wikis.

Overall wikis can be an interface of a document repository or even replace it, they can be used as a PM tool and a collaborative environment for employees, or for promoting initiatives instead of a newsletter. The impact that wikis might have extends beyond the first phase of the KM model, since they add a collaborative element to the management of explicit knowledge and allow employees to co-create knowledge, therefore contributing to enabling knowledge sharing and even creating new knowledge.

Blogs

Blogs became quickly widespread as a lightweight and unstructured tool, easy to publish and access an entry (Wagner and Bolloju, 2005), thus lowering the barriers for sharing, and as a topic oriented tool to reach a targeted audience and generate discussions around specific issues (Hsu and Lin, 2008). In the corporate environment more and more companies start using corporate blogs mostly as a PR tool or a channel for corporate communication, as a discussion platform or sometimes as a PM tool (Grudin, 2006). Built chronologically, blogs enable efficient search and information retrieval through tagging and can generate fruitful discussion through the commenting functionality (Cayzer, 2004; Grudin, 2006; Klamma et al., 2007), thus ‘contextualising knowledge conversationally’ (Davison et al., 2013, p. 96).

Blogs were discussed much less than wikis by the interviewees, but the centrality analysis showed that the blog was the fifth most influential concept in Company 5. This finding suggests that blogs might become a useful and powerful tool primarily in the later phases of KM, as a supporting tool in creating new knowledge.

In the companies interviewed blogs were mainly used to downstream high level corporate news and were seen as a high profile news feed. Some companies adopted Twitter and LinkedIn to streamline news, of which LinkedIn was also used internally. Two companies saw them as a way to democratise information about ongoing activities or the most interesting projects. One of the companies used a blog as a marketing tool to offer more sociable and less dry information about some of their projects to an outside audience. The company asked various project teams to write not only an update on projects but also a narrative about their experience (e.g. about problems with customers or weather challenges). The other company used it to provide updates about a new project internally, generate interest in different divisions, excite people and prepare the ground for implementation. Similarly, these updates were written in a more human and engaging language, and were a way to receive feedback from peers. This company also started experimenting with formats, and found that video blogs were viewed four times more often on average than text entries; however, creating just one video post was significantly more time and resource consuming.

Overall, it was possible to find far fewer examples of blog application than wikis; they create room for collaboration as opposed to newsletters or the portal. However, their perception is still limited to being a more sociable form of newsletter, which becomes increasingly important, as KM evolves in an organisation.

Forums

Forums are among the earliest adopted social computing tools (Wagner and Bolloju, 2005) and are widely used to address problems and urgent requests raised by colleagues (Voelpel et al., 2005). Forums became popular mainly due to their simplicity and extra features, such as rating of posts and reading statistics, which help to identify and “stick” popular topics that would be lost or duplicated otherwise (Wagner and Bolloju, 2005).

The companies interviewed use forums mainly to post news and sometimes as a question & answer (Q&A) page being an alternative to emails. Forum-type software vendors (e.g. Yammer) promote it as a tool to help create communities of practice; however, in one company that has online communities the activities were mostly limited to posting news and updates. Some companies use it as a communication platform with their partners, where they can share information about ongoing projects and find information about past projects.

One of the major problems associated with implementing a forum is gaining and sustaining momentum by creating a stable and sufficient number of active users so that those who are willing to share are not discouraged by low participation, and others keep coming back because the space is active, a problem that is frequently discussed in online communities (Yang et al., 2017). Companies 1 and 2 faced these problems. One of them shared their experience of implementing a forum, which was very popular during the first two months, but was forgotten afterwards. This problem is rooted in the natural distribution of users in online communities. According to various estimates the percentage of non-contributing members or so-called lurkers (readers only) varies from 45 to 90% (Nonnecke and Preece, 2000), and of the remaining 10% only 1% are heavy contributors, creating up to 90% of the posts (Jakob Nielsen, 2006). Various attempts to change this distribution did not succeed, and therefore the researchers recommend to accept this fact as inevitable.

In this situation major contributors can be understandably demotivated, and visualising the activities of the silent users could help to make the system more transparent, e.g. rating or liking posts can indicate that others read them and find them valuable. As a side effect, contributions with higher ratings will move to the top, therefore helping the rest of the community see the most important and relevant information first. Rewarding contributors with expert points for their contribution might encourage them to maintain activity, and help identify experts in various fields. Such experiments have already been successfully conducted in the past (Voelpel et al., 2005). Rating and other tools are examples of gamification which has already been

mentioned in the discussion of document repositories and which we believe to be an important next step in the development of KMS.

Overall, the interviews showed that though forums can be adopted for various purposes, they are most appropriate and convenient for posting news and updates (including job searches) in a community, or as a Q&A space. But the benefits for the type of practitioners involved in this research were less obvious than that of wikis.

Other types of KMS

During the interviews we did not observe KMS types that would be connected to the beginning of the first phase or specifically dedicated to the third phase of the model (Figure 5). This might have occurred due to the selection bias of the companies, whereby only those companies that already engage in KM, and therefore are able to see related problems and at the same time have not excelled in it, will see the value in this study and agree to participate. Regarding the initial phase of explicit knowledge management we assume that at the beginning such companies would pay attention to data management and invest in databases, and these issues have not been brought up by the participants, because such systems are already in place and function reasonably well. Regarding the phase of creation of new knowledge such assumptions are more difficult to make. However, one of the interviewees mentioned gamification technique as a possible way to enhance existing KMS. The early findings in the use of gamification in KM (Shpakova et al., 2016) and KMS (Suh and Wagner, 2017) suggest that gamification might be the next step in developing KMS with a stronger focus on supporting the creation of new knowledge as an essential part of innovating activities.

Regarding the other types of KMS that have not been mentioned in the overview of the results, some of the types of technology, e.g. expert systems or knowledge based system, although included by some researchers in the scope of KM (Hendriks and Vriens, 1999), were not associated with KM by practitioners, but are rather seen as applications for specific areas of work. In the literature review we have discussed that these tools might be company specific and therefore too difficult to study within the scope of KMS, which tend to be associated with more generic tools, and this finding confirmed the observation. Discussing them in the literature within the scope of KMS might as well misrepresent KMS or blur its boundaries, since they are more likely to be applied and adopted to address specific business needs, and so have different issues associated with them.

To summarise the findings, the interviews helped to set the priorities and understand better the fit of each KMS type within KM. If we think of the types discussed above using a house as a metaphor, a document repository would be the foundation of the house and wikis would be its walls and front door, constituting the major part of the technology infrastructure for KM. LinkedIn could replace traditional profile libraries and become windows, through which one could get a glimpse of the inhabitants of the house. A forum could be a balcony, where knowledge workers share thoughts and seek help as well as interact with their neighbours. And finally, as the house is being built, it needs a roof and a chimney in the form of blogs, which streamline activities and show that the house is inhabited. This metaphoric example helps to emphasise the differences these KMS types in the context of innovative companies, but what is even more important is finding the right balance between KM practices and their reliance on technology.

Discussion

The developed model defines the role of technology in KM. The first phase of the model proved to rely substantially on technology, though technology alone is not sufficient. Starting from the second phase the importance of technology decreases, as it cannot fully support sharing the rich and diverse knowledge that the company starts to recognise, and less so the creation of new knowledge. Additionally, the model clarifies the areas of application of different types of KMS, where document repositories and wikis are believed to make most impact, while other types have more specific areas of application and can be a useful addition to the technological core.

Though the model suggests a natural progression through these phases, the phases are also interconnected and mutually reinforcing. In particular, practices in the consequent phase might facilitate improvements in the preceding phase; however, they cannot create the practices on the preceding phase, if those were absent. Subsequently, this model creates expectations regarding the types of KMS that should be at place in different phases of engagement with KM.

The interviews were mainly focused on the types of KMS and the ways in which they were used, but two other topics were recurrently brought up by the interviewees, i.e. KMS adoption and motivational aspects. These two topics are interconnected and can impact the success of a new KM initiative as much as choosing the right type of KMS, therefore it is worth reviewing them in more detail.

KMS adoption

The interviewees have encountered a number of problems associated with the adoption of KMS, including lack of training and rules of engagement. Some of the participants also mentioned the need for internal PR of KM, which would popularise a new initiative and supporting systems, and suggested that different generations might react to a new initiative differently. The insights about the adoption of KMS were somewhat related to the implementation of KMS. The literature on KMS implementation is scarce and limited to a set of generic steps (O'Dell and Huber, 2011; Voelpel et al., 2005). However, within the literature on the IS implementation it was possible to find a framework that helped to partially explain the observations.

Lapointe and Rivard (2007) suggested that the success of IS implementation is defined on three levels: individual, group, and organisational, which mirror the organisational levels (Crossan et al., 1999). The individual level refers to the individual acceptance and is usually influenced by the technology acceptance of the system and perceptions of it. The group level is characterised by the group interests and can create resistance due to the perceived loss of power by the group. Organisational level implies the alignment of the system with the organisational structure and business processes. The framework suggests that the failure to meet the requirements of one of these levels might cause the project to fail, and at the same time weaker support of one of the levels might be compensated by the overwhelming support on the other levels.

In relation to the companies where the interviews were conducted, the individual and group level play the same role as in the study described by the scholars: perceived usefulness and ease of use influence the adoption of the system, but are not enough if the system is not accepted at the group level. For instance, some of the interviewees reported that they were reluctant to adopt a new system, which they admitted to be user-friendly, because they did not see others getting involved with it. The need for training, which was also mentioned, only emphasises the importance of technology acceptance at the individual level: even if KMS are easy to use, the lack of time required to learn might cause resistance to adopt. The lack of rules of engagement can prevent the adoption at the organisational level as practitioners need to understand how the system should be used and what for, and how it is aligned with the business processes. This aspect also includes making the benefits of using the new system obvious for everyone, and requires a certain level of formalisation (e.g. officially recognising someone for contributing

to the new system, like a blog, and therefore signalling that it is an important activity and is not seen as a waste of time by the managers).

The organisational structure of the case companies predominantly resembles adhocracy, characterised as being organised around the projects and being composed of highly-skilled professionals (Mintzberg, 1980). In this setting the professionals tend to group around skills and hold a relatively high degree of decision making power. However, they are also grouped around projects, and if a PM process is routinized in the company, then it is possible to align the system with these routines, and this is where formalisation might play an important role. And the interviews showed that when the system required extra effort to use it in addition to everyday routines, the system was adopted more slowly or not at all. The material obtained during the interviews is not sufficient to suggest a new approach to implementing and adopting KMS, but these findings could be a good starting point for future research.

KMS and motivation

KM researchers have been engaged in quite an active discussion around motivation and it produced mixed results (Shpakova et al., 2018). The impact of tangible rewards has shown positive (Grant, 2013; Voelpel et al., 2005), negative (Vassileva, 2012; Voelpel et al., 2005) or no (Hsu and Lin, 2008) effect on encouraging certain actions, such as knowledge sharing through KMS. Such factors are often divided into extrinsic and intrinsic motivation, but the border is being blurred, and such factors as personal ties (Wang et al., 2011), or the sense of altruism and enjoyment of helping people (Ardichvili et al., 2003; Hsu and Lin, 2008; Kankanhalli and Tan, 2005), are often mistaken for intrinsic, though they are certainly closer to intrinsic motivation on this spectrum than monetary rewards (Ryan and Deci, 2000).

The interviews echoed the diverse and contradictory findings in the literature. One interviewee shared experience where an expensive monetary award (a car) had a corrosive effect on the employees in the company, while in another company a high-value award (a trip) had an overall positive outcome. It is possible that the nature of the awards makes a difference here, i.e. whether the reward is consumed (trip) or remains as an object that demonstrates the award (car), and the corporate culture probably also makes a considerable difference. Another interviewee suggested that the same person is motivated differently at different points in time. Another one saw rewards as being monetary and non-monetary, and considered a combination of the two to be the most effective.

“Before you start giving your idea, you see what’s in for you, and if there is a monetary aspect, you are more motivated to participate. Then if there is a non-monetary incentive, you are motivated to give a good idea.”

In some companies, being able to spend part of your working time on developing your idea was a sufficient motivation for people to contribute to the ideation forum, while in another company people were offered a substantial monetary reward for their ideas, and both approaches were successful. In Company 5 rewards appeared to be one of the most central concepts in the centrality analysis.

The contradictions in the literature and in the examples discussed above prove that the current way of looking at motivation has its flaws and does not help companies to make decisions. Nor does it help to explain the phenomena observed. For example, the expectation to be rewarded for innovative ideas might be driven by a sense of fairness of being rewarded for profiting the company, which is related to a sense of trust (Cropanzano and Mitchell, 2005) being a mediator of knowledge sharing (Chen et al., 2014), as opposed to the motivation where knowledge sharing is related to helping individuals rather than the company and its profits. And in this case the willingness to share knowledge is linked to reciprocity (Konstantinou and Fincham, 2011) and the expectation of receiving help in the form of knowledge sharing in the future. There might be a lot of other reasons for sharing or not sharing, such as hidden blocks in the corporate culture, and creating incentives in order to improve motivation rather than looking at the problem as a whole (Alavi et al., 2006; De Long and Fahey, 2000). This is similar to battling the symptoms that are easy to observe, instead of searching for the root-cause of the disease.

It seems that motivation is only an excuse for making others do a job that is not interesting. For instance, intrinsic motivation has been acknowledged as being the strongest type of motivation (Ryan and Deci, 2000), and it cannot be manipulated or reinforced externally, but it can only come from inside. Therefore, regardless of how much time we spend discussing it, we cannot change it. Giving recognition to experts is a type of reward that has proved to be an effective extrinsic motivation (Grant, 2013; Hsu and Lin, 2008; Voelpel et al., 2005). But it is only fair to give them recognition anyway.

Conclusions

In this paper we reviewed different types of KMS and examined their role in KMS in the KM model developed in the first part of this study (the organic roadmap of KM) in the context of

innovative companies with the example of the energy sector. From the different types of KMS that had been identified in the literature review, two types of KMS were found to be the most important: document repositories and wikis. In particular, the first phase of the KM model is centred on the KMS which aims at organising data, information and articulated knowledge as a part of data and document management. Document management in turn helps to facilitate explicit knowledge sharing with the help of document repositories, creating an overlap with the second phase of the KM model. As KM evolves further, the role of KMS becomes secondary. One type of KMS that was found to be particularly useful is wikis, which can be utilised both complementary to document repositories and as a replacement for them. They were mostly praised for their collaborative environment, which can support certain types of knowledge sharing, and for their ease of use and flexibility. The next element of KMS support that could be transformational is a gamification layer that can be added to any type of KMS.

Among other KMS types generic tools such as forums and blogs were found useful in specific areas of application, and could be utilised complementarily to the main tools. More specialised tools, such as expert systems, were not associated with KM by practitioners, thus it might be worth reconsidering whether they should be included in the scope of KMS research.

In this paper we revise the role that technology plays in KM and offer a balanced view whereby the importance of technology as well as the types of KMS that the company can benefit from change with time as an organisation progresses on the KM journey and adopts new KM practices. The findings align with the process view of KM which does not favour either technology or social aspects of KM, but rather looks at them combined. In particular, we have shown that the technological support for the KM initiative and its importance change as KM practices evolve. Technological support is essential at the beginning in order to help organise explicit knowledge, and as an organisation progresses and starts cultivating more interactions between knowledge workers, the technology support becomes limited. These findings are tailored for the type of the companies that were interviewed as noted further in the limitations section, specifically innovative companies that structure their work around projects. A similar research in other types of companies might reveal that other types of KMS are more beneficial for them.

On the practical side, this research defines the priorities and draws the boundaries between different KMS, and therefore helps in navigating through a wide variety of KMS tools available and making decision about the technological support of a KM initiative in a company. This

research also helps to set reasonable expectations from each of the KMS types and emphasises their purpose and limitations. For example, document repositories were seen as a useful and necessary tool by all the participants, but only for the purpose of navigating through the vast amounts of codified knowledge. With regards to knowledge sharing, if it needs to be mediated through IS, knowledge repositories could be complemented or replaced with wikis, as a better fit for collaborative work. However, even this tool would not be able to fully support knowledge sharing in all its forms, e.g. thinking together (Pyrko et al., 2017).

With regards to the companies sampled, it is possible that we have not observed the worst and best cases. Of the approached companies it might be that only those that have already started paying attention to KM and seeing the range of problems associated with it, but have not excelled yet in solving them, agreed to participate in this research. However, we tried to address this limitation by investigating the past experiences of the companies. In particular, all the companies admitted that they had properly functioning IS for handling large amounts of data, which for those of them who had worked in the same place for a long time has not always been the case. With regards to the best examples of KM practices and KMS use, we have identified one trend which might help companies to achieve a quality improvement in KM with KMS support, namely the use of gamification. Among others, gamification can make KMS more interactive, which in turn might result in better knowledge sharing and learning (Pallud, 2017). The early studies in gamification have demonstrated that it can have a substantial impact on KM (Shpakova et al., 2016), innovative activities (Roth et al., 2015) and KMS in particular (Suh and Wagner, 2017), and this area is suggested as one of the directions for further research.

Apart from that, this research was conducted with companies of a particular type, which were technology intensive companies from the energy sector with the organisational structure leaning towards adhocracy. In other industries and types of organisational structure dominant KM practices and supporting types of KMS might be different, and investigating companies of other types is suggested as another direction for further research.

Regarding other findings, we suggest new ways of looking at the adoption of KMS. In particular, examining the frameworks that are used in IS implementation might help to understand the reasons behind certain KMS systems being adopted or not. We also found contradicting findings regarding motivation aspects in both the results and the literature, where the same motivation factors might work differently in different contexts. These findings

suggested that the way we examine the aspects of motivation in the context of KM might lead to oversimplification of motivation, and this might be another direction for further research.

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