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Interfaces with Other Disciplines

A dynamic model of knowledge management in innovative technology companies: A case from the energy sector ☆

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ABSTRACT

This paper presents fresh insights into how medium to large innovative technology companies in the energy business evolve their knowledge management (KM) capability. To date existing models of KM have been static, while this work provides a more dynamic approach. The primary data is analysed using a combination of an operational research (OR) approach (causal mapping) with a well-established generic qualitative research method (the Gioia method). This paper contributes to KM literature by developing a dynamic model of KM, which shows how KM capability evolves over time within an organisation. In this model, KM evolves from managing explicit knowledge through knowledge sharing to creating new knowledge. Such understanding of KM as a process can help managers in decision making with respect to both KM and innovation activities.

1. Introduction

Peter Drucker was the first to talk about the importance of increasing the productivity of knowledge workers as the greatest managerial challenge of the 21st century, comparing it to the need of increasing the productivity of the manual workers in the 20th century (Drucker, 1969). Both large and small organisations have since embraced the importance of their knowledge-resources and embarked on a journey of knowledge management (KM) improvement (Davenport & Prusak, 1998; Nicolini, Gherardi, & Yanow, 2003; O'Dell & Huber, 2011). Although there are no periodic accounts of failure rates of KM projects, the evidence suggests that they are high (Akhavan & Pezeshkan, 2014); at least 50% as reported by the practitioners (Bloomfire, 2019).

While many studies have analysed the reasons for KM failure (Akhavan, Jafari, & Fathian, 2005; Braganza & Möllenkramer, 2002; Storey & Barnett, 2000) and developed recommendations for KM initiative implementations, much fewer attempts were made to investigate the differences in KM approach in different types of companies. If organisations are recommended to adopt different innovation strategies, e.g. based on their organisational structure (Lam, 2005; Mintzberg, 1980; Tidd, Bessant, & Pavitt, 2005) or strategic choices (Dörfler, 2010a; Miles, Snow, Meyer, & Coleman, 1978), then it seems reasonable to expect that equivalent logic might need to be applied in the matters of KM. However, the efforts are often focused on the technology side (Alavi & Leidner, 2001; Kankanhalli & Tan, 2005; Vaast, 2007), which is easier to understand (Davenport, 2005), than the substance it is meant to manage, which is elusive, hard to evaluate, and sometimes even identify (Fahay & Prusak, 1998; McDermott, 1999; Sveiby, 2001). Success stories of large organisations are often context-specific and capture the experience of a onetime intervention rather than a process (Brown & Duguid, 2000; Curet, 2003; Voelpel, Dous, & Davenport, 2005), thus making it difficult for other companies to relate and learn from that experience.

The existing KM models are also predominantly static (Rollett, 2012), because they represent a snapshot of KM in companies, a state at a particular point in time, rather than a KM process evolving through different states between different points in time. If such models were developed at a different periods in the same company, the models would likely be different. Of course, such large-scale longitudinal studies are exceptionally difficult to carry out and the findings could be difficult to attribute to KM evolution as distinct from the state of the context. Therefore, in this study we have taken a different approach. We look at different companies who are at different states of KM evolution at the same point in

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time, and therefore the change in the context becomes unproblematic. Thus, our study addresses the deficiencies of the static models and contributes to the literature by mapping the process of natural evolution of KM in companies – offering a dynamic model of KM.

Dominant decision aid models in KM (Davenport, 2005; McIver, Lengnick-Hall, Lengnick-Hall, & Ramachandran, 2013; Wenger, White, & Smith, 2009) can be characterised as reflexive. Unlike objectivist and conformist approaches, which aim at building an optimal model based on justified assumptions (Meinard & Tsoukiàs, 2019), reflexive models have no unquestionable reference points. A typical example of such models is socio-technical intervention (Checkland, 1999; David, 2001), where KM also resides. The importance of both social and technical aspects of interventions and the problematic nature of balancing them in KM (Alavi & Leidner, 1999; Roszak, 1994) help to understand why building better and better KM models, and then using them to support decision making in KM, is both important and problematic. Furthermore, considering the shift towards a knowledge-based understanding of organisations (Spender, 1993, 1996; Spender & Grant, 1996), gives not only exceptional significance to KM decisions but also signifies all decisions being increasingly knowledge-based, making adequate flexible and adaptive knowledge-based decision support tools paramount.

The purpose of this study is to explore the process of natural evolution of KM in medium to large innovative companies from the energy sector. Innovative companies were chosen, because creation of new knowledge and surrounding knowing processes lie at the core of their activities (Doz & Wilson, 2012; Leonard-Barton, 1995), and thus KM-related issues might be more visible there. The energy sector was chosen as one that has the tradition as well as the innovation, and having the companies from one sectors improves the comparability. Medium to large companies are consider as the functional division of work is higher, and therefore KM activities can be better observed. The analysis was based on the combination of two methods: causal mapping and the Gioia method of establishing second order themes. Causal mapping established itself as a soft operational research (OR) method for system analysis (Eden, 2004; Laukkanen, 1994; Shaw, Smith, & Scully, 2017) and was found appropriate for this research, because it allows us to look at an organisation as a knowledge system (Tsoukas & Mylonopoulos, 2003). The Gioia method proved itself in qualitative research as a robust approach to analysing contextually rich material (Gioia, 2004, 2013; Langley & Abdallah, 2011) and here it is used complementary to causal mapping to enrich the model with more specific details. The main contribution of this study is a proposed model of KM, which can support decisions concerning KM in innovative companies. It introduces a model that illuminates the evolution of KM practices in innovative technology companies within one sector (the energy sector). The paper contributes to the KM literature, which so far lacks equivalent models. It also offers a fresh approach to the practice of KM by looking at it as a dynamic process.

The rest of the paper is structured as follows. The next section defines KM and discusses the existing KM frameworks that were used as the basis for this study. The following section reviews the research context and the methods that were used for data collection and analysis. This is followed by the summary findings and presents the KM model derived from the analysis and a discussion of the role of this model for innovative companies. Finally, we draw conclusions regarding contribution to scholarship and practice and note further research directions.

2. Decision aid in knowledge management

A dominant view of KM in the literature suggests perceiving it as a set of practices embedded in the business processes that lead to a better performance (Bassi, 1997; Davenport, 2005), or as an effort to encourage knowledge increase and dispersion to create value (O'Dell & Huber, 2011). In this view knowledge is fundamentally grounded in human experiences and thus inherently either tacit or rooted in tacit (Polanyi, 1962). Therefore, explicit knowledge is only a part, arguably a smaller part, of what the knower knows. The tacit component cannot be shared directly, as we cannot tell, but it can be observed in practice through the means of thinking and doing. Consequently, such knowledge can be acquired by a knowledge seeker only through interpretation using their own experiences or through exploring one another's understanding of a particular issue (Davenport & Prusak, 1998; Pyrko, Dörfler, & Eden, 2017). Knowledge is constructed in a social context (Sergeeva & Andreeva, 2016) and converted into action through the processes of knowing (Dörfler, 2010b; Polanyi, 1962). This makes knowledge a potential or a capacity to act (Sveiby, 1997), where knowledge is comprised of framed experiences, values, contextual information and expert insights, allowing the knower to incorporate new experiences and information into this framework (Davenport & Prusak, 1998). Herewith, knowing processes are embodied in KM practices, and thus scholars study knowing processes by observing KM practices.

The duality of knowledge and knowing (Dörfler, 2010b) mirrors the relation between innovation and KM. New knowledge is at the core of an innovative idea (Doz & Wilson, 2012; Leonard-Barton, 1995), where innovation is seen as an output (Christensen, 1997; O'Reilly & Tushman, 1996). At the same time, knowledge and knowing processes enable innovating (Lam, 2005; Santos Arteaga, Tavana, Di Caprio, & Toloo, 2018; Swan & Scarbrough, 2001), e.g. the process of learning and creating new ideas (Arikan, 2009; Lam, 2005; Swan, Newell, & Robertson, 2000), engagement between people within the organisation to stimulate knowledge dispersions, which in turn can improve the innovative capacity of the company (Doz & Wilson, 2012; Van de Ven, 1986; Yu, Lan, & Zhao, 2018). The dual nature of interrelation between KM and innovation, when coupled with the complex and subjective nature of both the knowledge work and the innovation phenomenon, produces a system of multidimensional complexity. Hence any attempts to quantify such system would seem inadequate, because with the increased level of systemic complexity, new qualitatively different properties emerge from a combination of parts (Wierzbicki, 2007).

The high level of complexity helps to explain the struggle with KM initiatives. We have chosen two decision support frameworks developed to aid KM system design, as both frameworks use characteristics of knowledge work as a starting point, and thus are relevant for the development of our argument. The first framework by Davenport (2005) characterises knowledge work based on the level of collaboration required to complete the work and the level complexity, which he defines as the degree of judgement and interpretation needed for this work (Fig. 1). Using these two dimensions, Davenport distinguishes four categories: transactional model (e.g. call centres), integration model (e.g. software development), expert model (e.g. medical practice), and collaboration model (e.g. investment banking). In relation to this study, researchers and development engineers are most likely to be located between the integration and collaboration model depending on the level of complexity of the developed product. Both groups rely heavily on collaboration, thus knowledge sharing might be one of the most important knowing processes for them, which is not surprising. While inter-organisational knowledge sharing in pursuit of innovation might seem to be a dilemma (Bernstein, Gürhan Kök, & Meca, 2015; Nair, Narasimhan, & Choi, 2009; Nasr, Kilgour, & Noori, 2015), intra-organisational knowledge sharing is genuinely believed to have a positive impact on innovating (Shih, Tsai, Wu, & Lu, 2006; Voelpel et al., 2005; Yu et al., 2018). However, further exploration of the balance between the other characteristics of the two models of

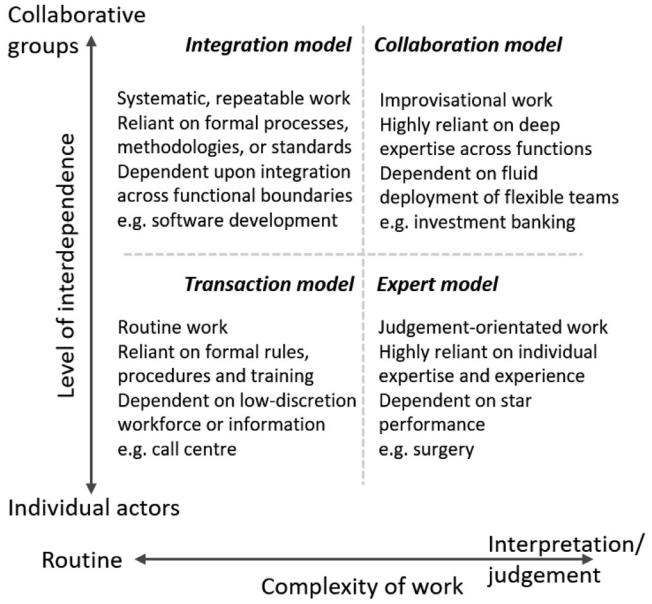

Fig. 1. A classification structure for knowledge-intensive processes. Source: (Davenport, 2005).

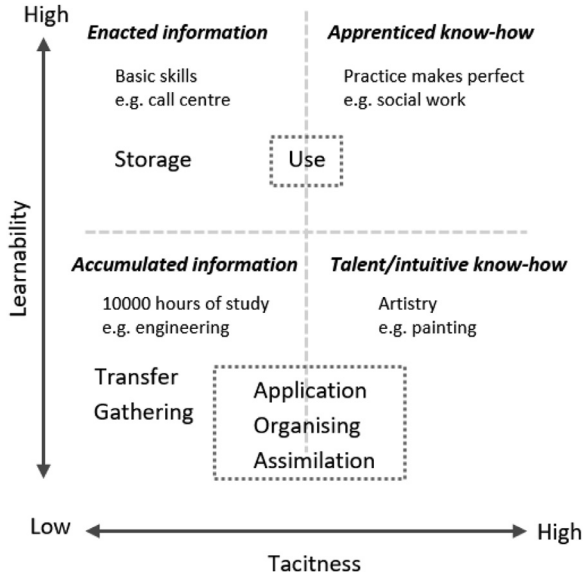

Fig. 2. Knowledge in practice types for organisational work. Source: (McIver et al., 2013).

knowledge work is required. In particular, standardisation level in integration model enabled by technology with its limitations (Li & Jhang-Li, 2010), might be in conflict with the heterogeneity of expertise in the collaboration model required for productive knowledge sharing and creation across the networks of innovators (Juani Swart & Powell, 2012).

In the second framework, McIver et al. (2013) clustered knowledge work by the degrees of tacitness and learnability of the required knowledge, where learnability is defined by the time and effort needed to absorb the knowledge (Fig. 2). The two dimensions form four categories of knowledge work: enacted information, accumulated information, apprenticed know-how and talent know-how. The enacted information category includes relatively easy to learn structured knowledge (e.g. call centres), while the accumulated information category similarly consists of structured information, which is however much more difficult to learn, (e.g. engineering). Both apprenticed and talent know-how rely on highly tacit knowledge, but the former can be learnt through the apprenticeship (e.g. social work), while for the latter the knowledge is very difficult to transfer (e.g. artistry). Engineers fit into the accumulated information quadrant, which partially aligns with the first framework. Although their work can be highly complex, large part of it allows for articulation and a degree of standardisation, making it transferrable through means of communication. Together with organising and assimilation, this process assumes the type of work that requires collaboration. The other two processes imply the need for research skills (gathering) and the ability to apply research insights, both of which characterise R&D activities.

The two KM decision aid frameworks complement each other and are aligned with the characteristics that one can expect to find in an innovation team of a technology company. The models are considered suitable for this study, because both of them use knowledge characteristics as their dimensions, which makes them comparable. Furthermore, these models align with our understanding of KM, and therefore, served as useful starting points. In this study, we set out to develop a dynamic model of KM, that shows evolution over time, and use these frameworks as an input. This allows for the possibility that priorities in KM practices evolve with time, in line with researchers' own experience and evidence from practice that suggests that KM practices have levels of maturity (Disraeli, 2006; Ehms & Langen, 2002; KPMG, 2000). Thus, we address a gap in the literature that recognises a process view of KM, but does not examine how this process evolves overtime. With a dynamic KM model that shows an evolutionary path of KM, KM practitioners and decision makers might be better equipped for designing a KM system and see it as a learning process. In this context, evolution is understood as a change of the dominating KM practices over time within the boundaries of one organisation. Therefore, the above frameworks are used as a starting points in investigating the flow of knowledge in innovative technology companies through the lens of knowing processes highlighted in these frameworks.

3. Methodological approach

The evolution of KM in companies over time can be observed either through a long-term study in one company, or by comparing the KM experience of several companies with different levels of involvement in KM. The first approach can be time- and resource-consuming, and carries uncertainties, e.g. regarding the duration of a KM evolution, which affects the necessary length of the study. In addition, the attribution of any insights is also problematic, as the context is changing over time as well. The combination of the two is also possible, but, although observing multiple companies over an extended period of time is logically sound, it raises substantial technical difficulties, for instance, the same person could not conduct all the observations, therefore, the comparability of the data would be questionable. However, it is possible to see how it is different in comparable companies that are at different stages of KM evolution. Therefore, using a multiple case study (Eisenhardt, 1989; Yin, 2014) research design seemed more appropriate. Section 3.1 (Methodological choices) discusses the chosen methods in more detail; then Section 3.2 (Methodological procedures) covers the contextual aspects of the study and the related procedures.

3.1. Methodological choices

The above discussion of the state of KM literature illustrates the existing frameworks for KM decision aid. Their limitations might be partially rooted in the research approaches, which ignore a continuously evolving nature of KM practices. A new model needs to

provide valuable means of managing the complex and subjective nature of such phenomena as knowledge or innovation (Tsoukas, 1989), akin to problem structuring (Rosenhead & Mingers, 2001). Soft OR methods have been used in knowledge structuring (Basu, 1998) and are linked to knowledge creation (Eden, Ackermann, & Cropper, 1992; Franco, 2013). Mapping methods, in particular, are a suitable approach to analysing qualitative data (Ackermann, Howick, Quigley, Walls, & Houghton, 2014; Shaw et al., 2017), as they allow for content analysis and descriptive comparison (Eden, 2004), and help to trace the chain of arguments in fragmented discussions (Shaw et al., 2017). Thus we are using an established OR method in combination with a commonly used (Gioia, 2004; Gioia et al., 2013) qualitative method of content analysis establishing second order themes, to develop a decision aiding approach to managing organisational knowledge.

3.1.1. Data collection

During the principal investigation we used *semi-structured* interviews with a fine balance between highly structured questions and unstructured dialogues, which allows for the abstraction of the deep insights from the interviewees and at the same time makes the interviews comparable (Saunders, Lewis, & Thornhill, 2019). With the balanced ratio between predefined questions and an open discussion the interviewees might unveil new knowledge to be explored in subsequent interviews, but the interviews can still be subject to exploring and analysing common patterns.

3.1.2. Data analysis

Of the chosen methods, causal mapping was used as a first step in the analysis, because it allowed us to capture the holistic picture of each case and reveal hidden patterns by comparing the cases. The emergent patterns, in turn, created a structure for content analysis using the Gioia method, whereby we could gain a deeper understanding of each element of the pattern, such as a particular KM practice. The two-step approach resulted in a structured and contextually rich model of KM.

Causal mapping

Causal mapping is used for structuring rich qualitative data through a graphical representation (Eden, 1988) which emerges through unidirectional links that indicate causal relationship between the concepts (Laukkanen, 1994) or, as in the context of this study, the participants' beliefs about how a particular process or practice works in a particular company (Bryson, Ackermann, Eden, & Finn, 2004). This method can be applied quite flexibly and has already been used in research for analysing individual interviews (Pyrko & Dörfler, 2018) and focus groups (Ackermann et al., 2014). Therefore, visual problem structuring can help to learn more about each company case (Pyrko & Dörfler, 2014) comprised of 5–6 individual interviews with relevant stakeholders in the problematic situation.

The resulting map with statements linked together captures a state of practice in a company as seen by the interviewees within the context of KM. There might be multiple relationships between the concepts and the relationships can show the phases of the process, e.g. a project team is selected and engages in project management, resulting in project documents, or they can indicate the consequences of the events, e.g. the inconsistency of work that prompted the implementation of standard procedures. The map should not be mistaken for a complete picture of a studied problem, but rather an imperfect representation based on the participants' perception of the problem.

The causal mapping part of the analysis was conducted using the *Decision Explorer*[3] software. Apart from helping to visually rearrange the map and indicate the central concepts, it also helps find reinforcing loops that emerge on the map. Centrality analysis, based on the cumulative connectivity score of each concept within a single map, allowed us to compare the cases and identify the patterns amongst recurring concepts across the cases. The reinforcing loops reveal non-linear possibly reinforcing situations (Eden et al., 1992), which would not have been identified otherwise.

[3] https://banxia.com/.

Second order themes

Similar to the question of a sample size in a qualitative research, the approach to analysing qualitative materials lacks well-established rules and norms; however, two methods have emerged as dominant for qualitative studies: Eisenhardt's (1989) theory-building from multiple case studies and the Gioia method (Gioia, 2004; Gioia et al., 2013). Both approaches have been praised and become widely popular amongst the scholars in qualitative research. The choice of the latter as a guiding template was mainly defined by the ontological position of this research (Langley & Abdallah, 2011).

The Gioia approach is driven by grounded theorising from practice in search of emergent themes. Although grounded theory in its original form also stems from a positivist framing, in the more recent versions the researcher is interested in the context, understandings and meanings of the participants, which is rooted in interpretivist assumptions, and tries to find the logical connections in the contextually rich empirical material on a timeline by drawing conclusions on the second order themes that emerge from the data. The classical Gioia approach is based on in-depth immersion with a single case and deep understanding of the rich context around it. While we are interested in the progression of KM in the company, and therefore, in interpreting the current state and underlying conditions in different companies that are likely to be engaged in KM in varying degrees. This method is often presented as a go-to 'recipe' for analysing a wide range of qualitative empirical material (Langley & Abdallah, 2011), but Gioia himself uses it adaptively depending on the context. Similarly, in this research it is used in combination with causal mapping to analyse the interviews that are part of the multiple case study analysis, where the insights are derived from both the literature and practice.

The original Gioia method follows a two-stage process. In the first stage, the qualitative material is "sliced" into pieces, and the relevant pieced are "coded" with nodes, which can be either predeterment or emergent. In the second stage, the emergent nodes are aggregated into parental nodes, which form patterns. Each pattern is then interpreted forming key insights about a studied phenomenon.

3.2. Methodological procedures

The research progressed as a dialogue between literature and practice, which seems appropriate given the subjective nature of the topic (Laverty, 2003). Three cycles of iteration between literature- and practice-informed research context (three rounds of interviews) also mirrored the dialogue between two methods, mapping and content analysis. The first round of interviews helped to develop the research context of this study with the key findings discussed in Section 3.2.1. The second round of interviews was conducted with KM experts, in order to validate the research design of the principal investigation and the main assumptions underpinning the chosen approach. The key insights from these interviews informed the discussion of the main findings and are presented in the Discussion in Section 5. The third round of interviews constituted the principal investigation – the multiple case study (Fig. 3). The energy sector was chosen for the principal investigation as an

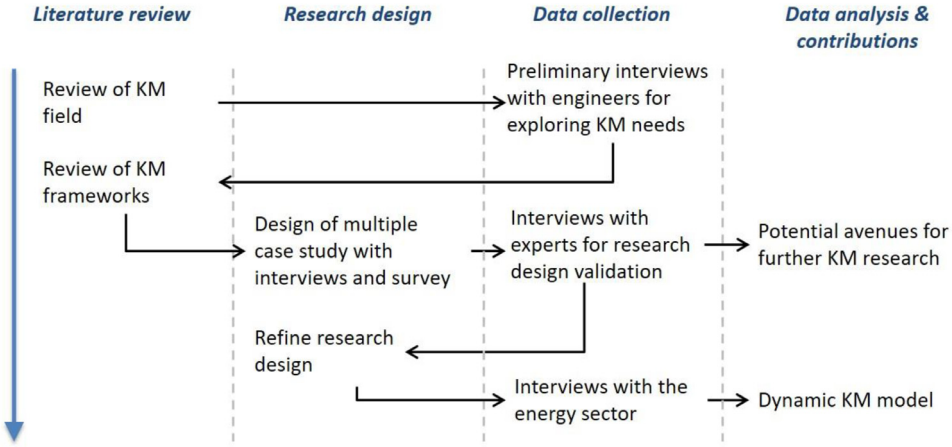

Fig. 3. Iterative research procedure.

industry representative of technology companies, because it constantly faces technological challenges and ambitious goals ahead, and so it could be an adequate place to look for innovative technology companies and observe the knowledge sharing phenomenon. By studying companies within one sector, energy, there was some attempt to ensure reasonable similarity of external conditions and that all the companies were operating in similar markets. The sample size and methodological procedures of this cycle are discussed in Sections 3.2.2 and 3.2.3 respectively, followed by the Findings section.

3.2.1. Research context

Following the objective of this study, we focused on R&D activities as an embodiment of innovating in an organisation and an example of a more knowledge intensive area, where managing highly contextual knowledge (Doz & Wilson, 2012) proved to be particularly challenging in the past (Voelpel et al., 2005). Combining literature review with preliminary interviews with practitioners, as the first iteration of this study, allowed for better understanding of the research context. We were specifically interested in comparing innovating activities and learning about KM related challenges from a practitioner (not KM expert) side.

For the preliminary investigation, the six interviewed participants were engineers from six different technology companies. They described their innovative activities through their product development processes (PDPs). The comparison of PDPs identified many similarities: the process usually starts with the ideation phase or a set of requirements, followed by detailed design, prototyping, testing and the production phase. One company also conducts pilot production, but they may require this step because, unlike the other companies, they make small serial products rather than custom-built unique products (Fig. 4).

Existing PDP frameworks focus on different stages of the process that reflect the background in which they emerged. For instance, the frameworks of Boothroyd, Dewhurst, and Knight (1994) and Peters et al. (1999) are based on engineering design methods with emphasis on engineering product improvement. Whereas the frameworks of Pugh (1991) and Ulrich and Eppinger (2000) are more generic, with the latter being a more detailed version of the former, incorporating organisational activities related to product development. When compared with the findings from the preliminary interviews, the framework of Ulrich & Eppinger matches the described processes the most (Fig. 4). This framework is based on the experience of various types of organisations, and the similarity with the companies in the preliminary study suggests that the process resembles that of other technology companies with similar profiles. Therefore, this process can be used as a primary activity during the principal investigation to ensure comparability of the results.

The analysis of the preliminary interviews also revealed differences in the organisational structure. The companies that are involved in the development of highly complex products tend to work on a project basis, leaning towards adhocracy as organisational structure (Mintzberg, 1980). PDP in adhocracies is blended with project management. Such companies have blurred boundaries between the departments, and this structure creates different dynamics between the knowledge workers.

Following the preliminary investigation, the sample requirements for the principal investigation were further adjusted by the number of employees. The preliminary investigations suggested that the experience of a small company (around 10 employees) was quite different from the others, e.g. it did not have problems caused by poor visibility of work, because it was quite easy for the CEO to track every activity in the company. Therefore, it was decided to focus on medium to large companies (over 50 employees) following the European Commission (2005) classification of the company sizes. After having clarified the characteristic of the companies for the main empirical part it was required to determine the sample size.

3.2.2. Sample size

The recommended number of interviews required to build a robust theoretical contribution in qualitative research varies from 30 to 50 (Morse, 1994), or 15–60 (Saunders & Townsend, 2016), to 20–30 for grounded theory (Marshall, Cardon, Poddar, & Fontenot, 2013), to less than 20 for a small scale exploratory study (Crouch & McKenzie, 2006). Concerned with imposing a positivistic frame on qualitative research (Pratt, 2008), other scholars suggest defining sample size by a point of saturation in the interviews (Morse, 1994) or informal redundancy (Lincoln & Guba, 1985). However, not achieving saturation does not invalidate the findings (Pratt, 2009), since the phenomenon might be partially explored, opening opportunities for further research building on the findings (M. O'Reilly and Parker, 2012). In the organisational and workplace research 30–50 interviews proved to be sufficient (Saunders and Townsend, 2016) with 3–5 interviews per case in a multiple-case study (Creswell, 2013). Following these guidelines, the principal investigation was based on 32 interviews with practitioners from 6 companies.

3.2.3. Principal investigation

During the principal investigation, the interviews were focused on the practices that surround the PDP and are related to the

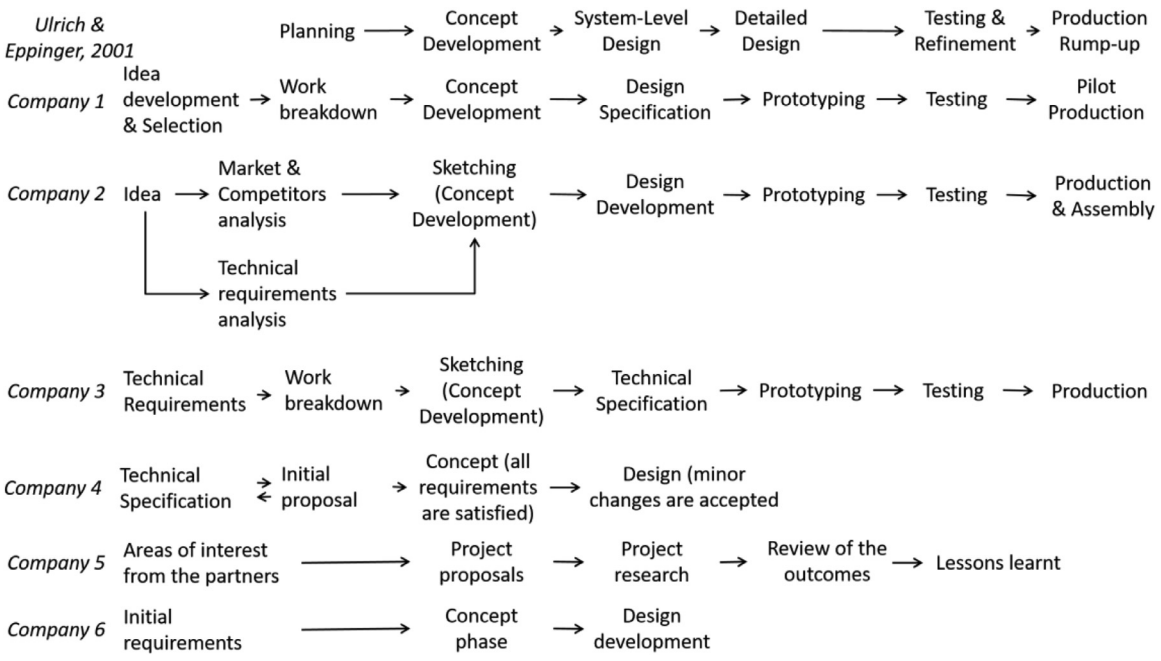

Fig. 4. Product development process in interviewed companies from the preliminary investigation.

knowledge flow in the company. They included various aspects of knowledge sharing as the core knowing process, aspects that were perceived as important by the practitioners interviewed in the preliminary study.

The interviewees were chosen from product development background with little or no experience in KM so as to share a first-hand perspective on KM issues with no preconceptions. 32 interviews were conducted with product development engineers and project managers from 6 companies (Table 1), each lasting from 30 to 70 min. The transcripts of the interviews from each company were mapped and analysed using the *Decision Explorer* software, after all the interviews were conducted, resulting in 6 aggregated causal maps. The maps were then validated with the interviewees. The transcripts were then coded in *NVivo* software[4] following the two-stage process of the Gioia method (see Section 3.1.2). The preliminary list of nodes was developed based on the causal maps, but new nodes also emerged during the analysis. The resulting 193 nodes were then aggregated into 18 parent nodes forming the emerging second order themes.

4. Findings

Upon analysing the cases, we observed differences in the involvement with KM between the companies. **Companies 1** (Fig. 5) and **2** had engaged in little knowledge sharing, and justified it by mostly not having time for it. Document management was poorly organised and some of the interviewees recognised it as a major issue. Although one of the companies had a formal KM team, it served mostly commercial purposes – to demonstrate the novelty of projects to the funder(s). Learning from past experience largely depended on the consciousness of project managers. **Companies 3** and **4** assigned a person responsible for KM and were mostly concerned with improving knowledge sharing between engineers and project managers. They emphasised lessons learnt having the potential to impact future work. **Companies 5** and **6** had well-established KM practices, and thus prompting these topics generated little discussion. They were quite satisfied with the quality of knowledge sharing across the company, though saw areas for improvement. The topic that resonated with the interviewees the most was the management of new ideas. Both companies dedicated resources to develop new processes for idea management.

4.1. The dynamic model of KM

For **Company 1** visually KM-related concepts, namely, *informal sharing, little communication* and *ideas,* are highly connected on the map, but only *little communication* has a high centrality score. This discrepancy suggests that KM-related practices are on the fringes of practitioners' attention and thus have little impact on their other activities. Interviewees have an opinion about KM, but it is not translated into practice. For instance, learning from reuse of past experiences occurs at the discretion of a project manager and is shared informally. Surprisingly, *self-defined communities* emerged as the third most central concept, thus impacting other activities. According to the interviewees, such communities are not formally recognised by the company and are even sometimes discouraged.

> "I keep telling the rest of the business, keep knocking their head against the brick walls: you've got to improve this if you want to get benefit from that. We are constantly trying to maintain this community because I see it fundamentally *as the basis for improving the business innovation.*"

For **Company 2** the most connected concepts are *ideas, lessons learnt, project dissemination, showcase projects document repository,* and *forum*. The map also evidences the commercial focus of the KM team: lessons learnt are important, but aim at disseminating the results and demonstrating the achievement to the outside audience. The outwards orientation is also reflected in the top central concepts. The *experience reuse* is largely based on *having the right people*, who will know what to do. The reliance on the right people is further reinforced by *no visibility of work* and *poor check for redundant projects* in a loop.

[4] https://www.qsrinternational.com/nvivo/.

Table 1
List of interviewees.

#	Interviewee experience	Interviewee location	Company	Sector	Size
1	New Hire	HQ	Company 1	Distribution Network Provider	250–1000
2	Medium Experience				
3	Experienced PM				
4	Experienced PM				
5	Medium Experience				
6	Medium Experience	HQ	Company 2	Distribution Network Provider	250–1000
7	New Hire				
10	Medium Experience				
8	Medium Experience	Remote			
9	Experienced PM				
11	Experienced PM				
12	Experienced PM	HQ	Company 3	Engineering consultancy	250–1000
13	New Hire				
15	Experienced PM				
16	Medium Experience				
14	Medium Experience	Remote			
19	Medium Experience	HQ	Company 4	Engineering design	250–1000
17	Medium Experience	Remote			
18	Experienced PM				
20	Medium Experience				
21	New Hire				
22	Medium Experience				
23	New Hire	HQ	Company 5	Engineering design	>1000
24	Experienced PM				
25	Medium Experience				
26	Experienced PM				
27	New Hire				
28	New Hire				
29	Experienced PM	HQ	Company 6	Engineering consultancy	>1000
30	Experienced PM				
31	Medium Experience				
32	Medium Experience				

Company 3 also formed a KM team, but its activities are inwards oriented, which is evident from more integrated KM concepts. Of the five visually connected KM concepts, namely, *informal communication, reuse of past projects, document repositories, wikis,* and *bad search, f*our have high centrality scores. The results suggest that the company has a reasonably well functioning document repository, which together with *informal sharing* enables the *reuse of the past experiences*. The informal mutual help is self-sustained both locally and internationally.

Similarly, in **Company 4** KM concepts, i.e. *lessons learnt, informal communities, ideas* and *wikis,* are well connected and have high centrality score (except for the *ideas*). In particular, informal communities that grow bottom-up help to maintain constant information and knowledge sharing about the corporate activities, e.g. updates and request for help: "…we are trying to stay on top of the things". Largely informal approach to organising work was captured in a reinforcing loop, whereby project managers rely on their large experience, and therefore have little acceptance of any attempts to make their work more coherent with each other, which in turn affects consistency. The company acknowledges the issue and makes an effort to organise more formal knowledge sharing events, like *annual summits*, which might help to address such problems. Based on the centrality score these events appear to have a significant indirect impact on other activities.

In **Company 5** the concepts related to knowledge sharing, i.e. *knowledge sharing, visibility of work, lessons learnt* and *networks*, remain connected, and thus perceived as important. Additionally, *ideas* become increasingly important. The centrality scores are high for most of these concepts and also for other KM-related concepts, namely, *informal sharing, providing updates, visibility of work* and *knowledge reuse*. The map contains several reinforcing loops. In particular, networks help to identify experts with required competences for project team, which allow for their expansion. They also help to reuse knowledge for new projects. Lessons learnt are a source of new ideas, while blogs are used to share them and also to provide updates on projects, which in turn maintains better visibility of work. All these insights suggest a healthy mature state of KM in the company.

Company 6 has been recently acquired by a large organisation, which explains some of the results of the centrality analysis. However, it retained partial autonomy and can be compared to a group of innovators sharing their creative products with the rest of the company. It is a particularly interesting case, because the company considers itself very successful at innovating. The most connected KM concept is *ideas*, which reflects their claims.

Fig. 6 highlights three patterns. (1) Learning from past experience grows in importance, with the exception of company 3, which might have been too critical about their poor performance in lessons learnt sessions. Lessons learnt were also not highlighted in the centrality analysis of company 6, however, the company considers them being an essential part of their project management, and even has their process ISO 9001 certified. (2) The emergence of ideas as an important concept as KM progresses is evident in companies 5 and 6. (3) The influence of document repository grows in importance, peaks in company 3, and then is displaced by social media tools.

This analysis supports the initial assumption about the evolving nature of KM in a company, as evidenced for the 6 case companies, and the evolutionary path can be divided into three phases: *managing explicit knowledge, knowledge sharing* and *creating new knowledge*. In the first phase a company learns to manage the knowledge that can be and is articulated, such as project reports and summaries, and improves the consistency of work through standards, procedures and templates. In the second phase the company learns to share the knowledge that is difficult or impossible to articulate. Informal sharing can be found in almost any company regardless of their engagement with KM, but we also observed other forms of knowledge sharing, such as sharing within communi-

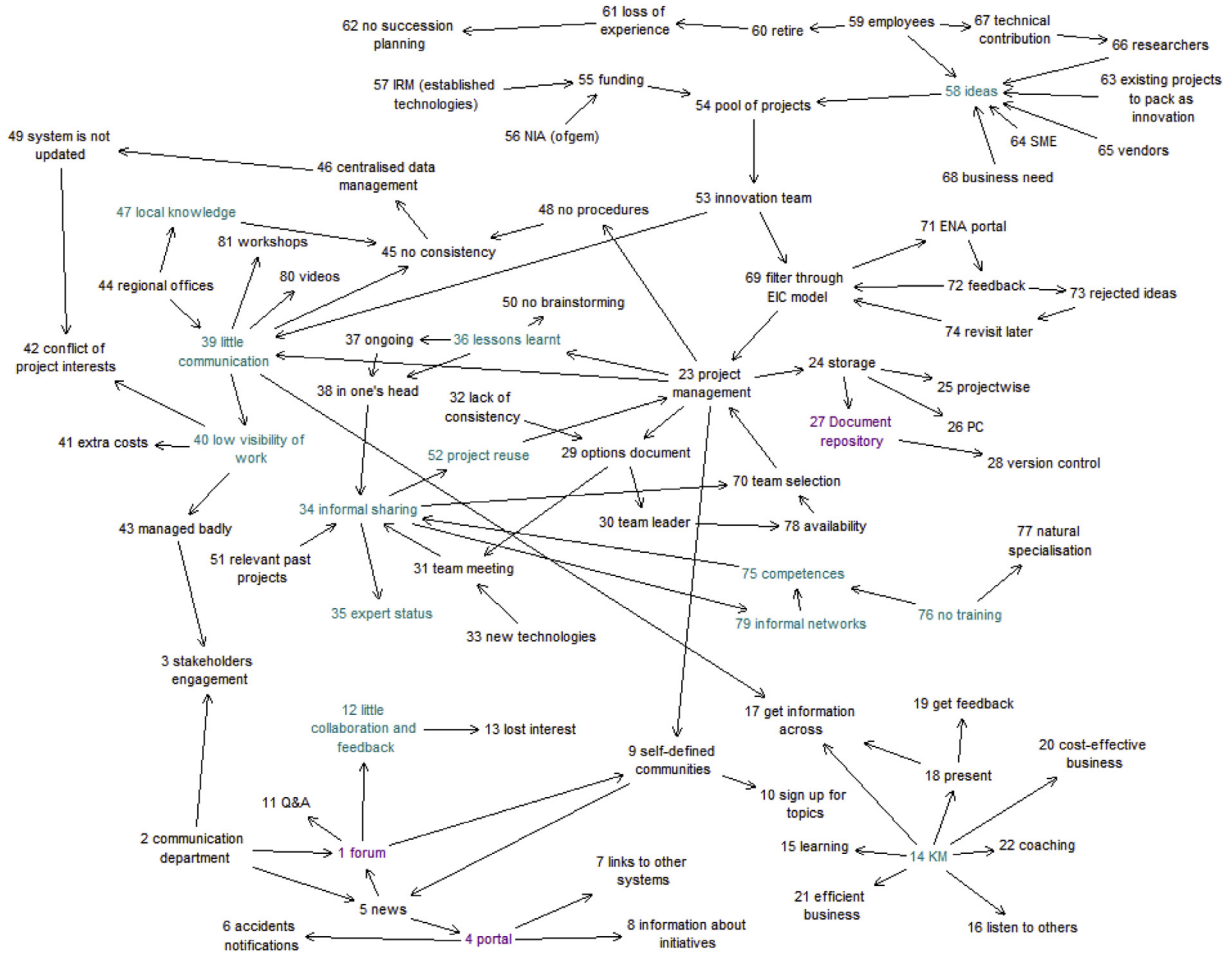

Fig. 5. Concept map of Company 1.

Company 1	Company 2	Company 3	Company 4	Company 5	Company 6
Project management (27)	Project management (28)	Engineers (30)	Project lead (34)	Lessons learnt (32)	Development (20)
Little communication (25)	Project documents (25)	Document repository (28)	Project team (30)	Ideas (30)	Ideas (18)
Self-defined communities (18)	Project dissemination (23)	Project team (26)	Project management (28)	Informal sharing (28)	Project pool (17)
Team selection (17)	Business as usual (21)	Emails (24)	Annual summit (23)	Project management (28)	Engineers (16)
Project filtering (17)	Identify key stakeholders (20)	Training matrix (23)	Lessons learnt (23)	Blogs (25)	Parent company (14)
Innovation team (16)	Learning capture plan (19)	Reuse (23)	Rely on large experience (22)	Network (22)	Permission (13)
Project reuse (16)	Document repository (18)	Project documents (23)	Wikis (22)	Update (21)	Workshops (13)
Lessons learnt (16)	Right people know (18)	CV (20)	Updates (21)	Rewards (20)	Project team (12)
Option document (16)	Lessons learnt (17)	Old projects (20)	Informal communities (21)	Visibility of work (20)	Templates (12)
No procedure (15)	Innovation projects (17)	KM (19)	Request for help (20)	Monthly reports (19)	3rd party (12)
Storage (15)	Resistance to change (16)	Project brief (19)	Team leader (20)	Knowledge reuse (19)	Target (12)
Informal sharing (14)	Job allocated adhoc (16)	Informal communication (19)	Technical request (20)	Report (19)	Monthly meetings (11)

Fig. 6. Central concepts.

ties and lessons learnt. The successful examples demonstrated intrinsically different approaches from managing explicit knowledge, thereby understanding and acknowledging the complex nature of knowledge (Tsoukas, 1989). In the third phase the case companies learned to facilitate the creation of new knowledge, an essential part of which is ideas management. Most companies tried to engage in ideas management, but only companies 5 and 6 succeeded in these initiatives. This observation suggests that the companies should naturally progress through the previous phases before the consequent one can have an impact on their activities.

The three phases, overlap with and influence each other, e.g. if creating new knowledge is facilitated through ideas competition, it has the potential to improve visibility of work and knowledge sharing. Conversely, in a company where knowledge sharing is not appreciated and encouraged, employees are less likely to share new ideas. Similarly, knowledge sharing helps to develop common approaches to work, which in turn improves the consistency of work and knowledge elicitation in particular, which may lead to increased knowledge reuse. In contrast, with poor document management practices knowledge workers simply do not have time to share knowledge. The efforts are limited to helping each other locate relevant documents. The resulting model of KM evolution is captured on Fig. 7 and outlines the key KM practices identified on each phase.

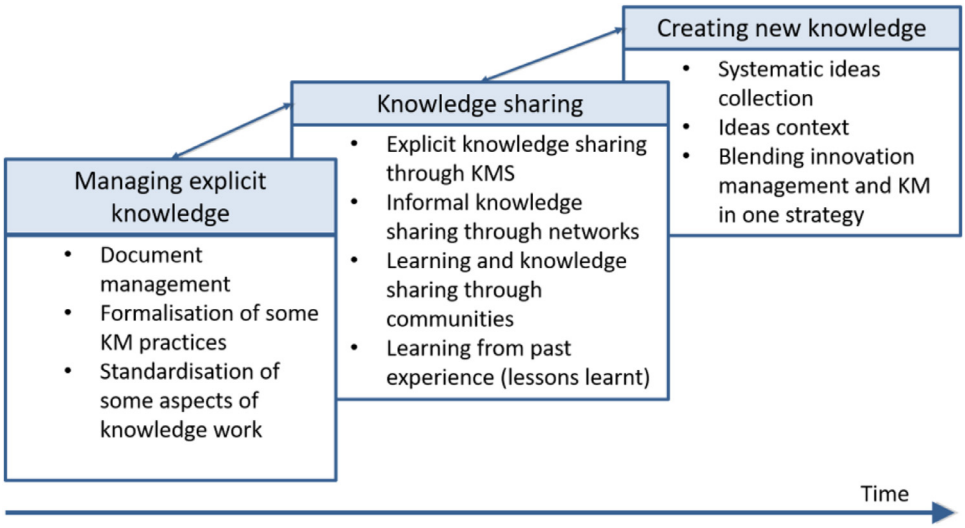

Fig. 7. The organic roadmap of KM.

This model advances thinking about KM capability development. It describes characteristics seen in companies at different stages of their KM maturity over time. Similar to the way in which Wheelwright and Hayes (1985) advanced thinking about manufacturing strategy, this model advances thinking in KM, with the practical contribution of helping managers to make better decisions depending on where they are on their KM journey. With innovation being such a key competitive factor these days, this model has important implications for managers. The model was informally validated with a group of academics and practitioners from Durham Energy Institute, who were representative of the energy sector. The purpose of this activity was to examine whether they would recognise characteristics, problems and practices identified in this research, as what they see in their experience, and whether they feel that what we developed was representative of their sector. The rest of this section explains in more detail the key parameters of each phase, as we reflect on the details of the findings in the light of the literature.

4.2. Managing explicit knowledge

Managing explicit knowledge is usually associated with capturing and codifying existing knowledge. With respect to knowledge capturing, older companies in the energy sector are largely concerned with knowledge loss and succession planning of the employees with decades of experience approaching their retirement age (Grant, 2013). The interviewed companies tried to capture the knowledge of "wizards" through exit interviews or through capturing their experience in a form of manuals, but non-surprisingly these attempts had very limited effect. Capturing 40–50 years of experience in a manual is hardly possible, because the most valuable part of the knowledge of these intellectually intensive workers is tacit and highly contextual (McDermott, 1999). Such knowledge can be transferred only through spending time with the knower (McIver et al., 2013), e.g. through apprenticeship (Stierand, 2015). One of the companies realised the complexity of the problem and started a two-year rotation programme for new hires. Engineering apprentices get a chance to spend time with highly experienced engineers many of whom are close to their retirement age, and to learn from them.

The parts of knowledge that can be captured, such as reports with the outcomes of the projects, best practices and lessons learnt, require formalisation. We observed a contradictory attitude to rules and regulations. The interviewees wanted to see the organic growth of KM, but at the same time, they suggested that a certain level of formalisation would make others take KM activities more seriously, especially when the changes are introduced. Reportedly, initiatives that are not directly related to their job and are not formalised tend to be ignored, suggesting that a degree of formalisation of KM practices is required.

> 'There is no clear process for managing information that goes on each platform, that's what's really lacking.'

> 'I've offered a part of this to my colleagues, but I'm pretty sure that it was not taken onboard, not because they ignore me, but because there is no formal way of doing that.'

Many interviewees also touched on the topic of standardisation, e.g. templates and checklists, and standard approaches of performing certain tasks, e.g. a gate process. For **Companies 3**, **5** and **6** it was usual practice that ensures consistency of work: *"…trying to make sure that all our reports and deliverables look similar"*. In the other three companies this topic had an emotional response:

> 'I've spoken with my colleague before about potentially trying to make a golden sample, where you know exactly what the standard should be.'

These findings are not entirely surprising – employees tend to focus on what they are evaluated on, what is part of their everyday job (Bassi, 1997; Davenport & Prusak, 1998). Formalising, recognising and setting the targets justifies the effort put in completing non-job-related activities or in changing the routines. One interviewee suggested an alternative to formalising – "legitimising" KM activities by inviting employees to participate in them through ratings or giving them non-material rewards, e.g. points. This approach resembles the mechanics of gamification, a technique that has already been trialled in KM context (Shpakova, Dörfler, & MacBryde, 2016), but is not widely adopted yet.

> 'It's much easier to encourage people to do something because they've been ranked on it every day and it's part of their actual job – to make sure that things have been run efficiently.'

KM literature also emphasises the importance of knowledge mapping, e.g. by tracking the experience of employees (Davenport & Prusak, 1998; O'Dell & Grayson, 1998). However, none of the interviewees saw the need for experience mapping, primarily because people naturally tend to look for relevant experts informally and seek for recommendations through their net-

work. One of the companies was tracking experience automatically through a document repository for external purpose, but knowledge workers did not find any use for this thoroughly documented information, partially because it provided only a vague idea of the competences of their colleagues.

4.3. Knowledge sharing

Interviewees provided examples of various forms of knowledge sharing, from formal knowledge dissemination through reports to organised events for face-to-face sharing and regular informal meetings of communities. However, they did not always associate these examples with knowledge sharing. The analysis of the interviews confirmed that productive knowledge sharing occurs in a common physical space (Davenport & Prusak, 1998; McDermott, 2000), e.g. during team meetings of informal casual conversations. While up to 85% of their KM budget can be spent on building a repository, only 15% of the value is gained from its use, and the other 85% comes from the interpersonal discussions (Grant, 2013). However, the companies associate knowledge sharing with and put significantly more effort in capturing, codifying and sharing knowledge through document repositories, as discussed in the previous section.

Companies 4, **5** and **6** also organise more formal events, e.g. conferences and workshops, of which sessions called "**Lunch & Learn**" proved to be particularly successful (in **Companies 4** and **6**). This format is used to educate people about new products or services, or new initiatives in a company. According to one interviewee *'it's a way to bribe people to come and listen to you for some free food'*. Yet, this format like any other face-to-face mode of interaction tends to naturally exclude remote offices. Video conference calls have limited impact on bridging geographical distance due to the time-zone difference and background noise.

In principle, geographical separation is not seen as a problem by the interviewees. They claim to be able to maintain working collaboration almost as effectively relying on emails, video calls and chat, but specific examples and stories shared during the interviews indicate the opposite. For instance, only employees of the head office participate in ideas competitions, because they find it easier to form teams in the same physical space. Those who recognise geographical separation as a problem address it by forming communities with their colleagues in order *'to stay in the loop'* (**Company 4**) or by intentionally forming mixed-office project teams (**Company 3**). Such 'tricks' force them to maintain regular communication about project-related matters and improve integration of the employees. Sometimes project-related conversations turn into more general discussions, e.g. about policies, standards, working practices.

> '…we kind of like to push each other a little bit and provoke each other saying: are you sure that it should be considered that way.'

However, the same approach had the opposite effect in another company (**Company 2**) and led to a disjoint project, because remote members found themselves in isolation.

> 'I am worried, that when we get to the end, we'll end up with a report and my report.'

Apart from facilitating knowledge sharing directly, the above events and approaches to organising project work aim at expanding *networks* of knowledge workers. Informal knowledge sharing occurred in all the case companies. Interviewees were more likely to seek advice amongst their immediate surrounding or within their network, where larger networks may make finding a relevant expert faster and thus improve productivity. Such targeted and spontaneous interactions represent one of the two aspects of knowledge sharing, the other one being communities (Wenger, Trayner, & de Laat, 2011).

An example of *communities* would be a group of electrical engineers working on new standards for solar energy. The interests of the community members lie outwith their main job responsibilities. They are driven by the desire to develop common practices, resolve contradictions, and learn together. The capacity to share tacit knowledge is what makes them highly valuable to a company (Grant, 2013; O'Dell & Huber, 2011), and is at the same time limiting their existence in an organisational environment (Von Krogh, 2011), because communities require a sustained effort to support knowledge sharing, e.g. through thinking together, which cannot be mandated (Pyrko et al., 2017).

In the case companies the identified communities formed around a certain profession or area of interest. In **Companies 1**, **2** and **3** the emerged informal communities were not supported by the management and attracted few people, primarily due the lack of time. In **Company 4** informal communities were well integrated in the main work activities, as evidenced by the centrality analysis. In **Company 5** communities were formally recognised, and in **Company 6** an effort was put into creating a community of innovators. The communities were mostly formed either around a profession, e.g. project management, or around an emerging technological area of expertise that had the potential to become an important strategic competence for the company, but still required a proof of concept. The communities were sharing their research findings, working on developing common standards and approaches to work, helping each other to learn, but not developing new breakthrough ideas. Their activities varied from spontaneous discussions about work practices to informal sharing of updates, moral support, and streamlining group activities.

The last observed knowledge sharing practice also includes elements of knowledge creating, as evidenced from the maps of **Companies 5** and **6**. Similar to sharing in communities, *lessons learnt* create conditions for more entrained knowledge sharing, e.g. by reflecting on the work or re-contextualising the knowledge, which most of the interviewees found difficult. Only **Company 6** was satisfied with the quality of their lesson learnt sessions and was proud to be ISO 9001 certified. **Company 5** used them as a source of new ideas. The others acknowledged the importance of lessons learnt and tried to include it in their work, but with varying degree of success. Some project managers used lessons learnt as a self-reflection practice, which enriched their experience and helped them learn, but the learning was not shared with others. Other practitioners included lessons learnt as part of a project closure, but the results of group reflection remained on paper.

The reflections were mostly focused on analysing mistakes, and less so on best practices. Interviewees agreed that learning from past mistakes was important, but cultural differences and resistance to admit mistakes in the western culture might be a natural barrier to such learning. For instance, a great deal of learning tends to be lost throughout a lengthy project, because the lessons learnt session only takes place at the end. If lessons learnt are included into the official report, they are most likely sanitised, lacking details that might seem inappropriate or unimportant. When done thoroughly, the insights might not be disseminated, or taken forward. Gathering and analysing best practices is seen as a separate activity. Based on previous experience, one interviewee recognised a repository of best practices as a useful learning tool at the initial stage of any project, but only **Companies 4** and **5** attempted to gather and share this valuable organisational knowledge. Knowledge sharing within communities and lessons learnt session might be the source of new ideas, as evidenced from the maps of **Companies 5** and **6**, thus these forms of knowledge sharing overlap with the next phase, which is creating new knowledge.

4.4. Creating new knowledge

When talking about new knowledge, the interviewees mainly referred to ideas, for which lessons learnt could be one of the sources. Hence, many discussions evolved around ideas management, whereby the interviewees did not distinguish between the ideas that could lead to process improvement and novel ideas that are traditionally associated with innovation (Christensen, 1997; Daft, 1982; Utterback, 1974). Ideas came from various sources, e.g. clients, employees in the field, lessons learnt, through a competition, or as a part of R&D. Most companies tried to create a formalised approach to ideas collection, selection and implementation, following the logic of the innovating process of Tidd et al. (2005). For instance, in company 2 an initiative called "*Licence to Innovate*" invited practitioners to submit an idea, and granted the authors of the best ideas two days of working time to develop their ideas further. Company 4 frequently ran *Hackathons* to collect new ideas or to test a new product as an alternative to ordinary trials, where the participants can be given a new product to play with and asked to find flaws in it or new areas of application.

Such initiatives normally yielded an abundance of new ideas, but many interviewees commented that implementing the selected ideas was much more problematic. For instance, an author of an idea might not necessarily be as good at implementing it, and as a result, sometimes good ideas vanish. Other idea faced resistance to change from the potential users.

> "You went to these guys, pointed this out to them, proved the concept, that one button would gather up all this network, export it. And it just didn't put things exactly how they wanted, they didn't really want to get involved in it, we couldn't sell it to them for *some reason."*

Apart from that, most initiatives are not fully integrated into the business strategy and aligned with other activities. For instance, one of the described initiatives exists in parallel with the innovation group. Another initiative idea is detached from the rest of the business.

> 'There are little bubbles of projects within the business that don't talk to each other. They are stuck in their own bubble, because they've got to deliver that as their goal.'

The lack of visibility of the results of the competitions demotivates future participants. Some interviewees could hardly recall anything related to these initiatives. Many of these problems mirror the challenges of the second phase of the KM model, and the link between the two phases discussed above suggests that unresolved problems with knowledge sharing might limit the potential for knowledge creation. In **Companies 5** and **6** ideas have high centrality score. Both companies put a lot of effort in improving lessons learnt. Both companies also tried to create communities of innovators. In other case companies informal communities were driving the creation of new knowledge forward. From here we take a leap and suggest that communities and lessons learnt may be a necessary foundation for improving knowledge creation in innovative companies.

5. Discussion

The proposed dynamic model builds on the KM models of Davenport (2005) and McIver et al. (2013), discussed in the literature review. The components of the model match the knowing processes that correspond to the investigated type of knowledge work. The developed model puts these processes in time perspective by suggesting different priorities at different phases of KM development. For instance, in the literature review we suggest that the investigated group of practitioners resides between the integration and collaboration type of knowledge work of Davenport, and some of their characteristics might be conflicting with each other. In this model the need for a certain level of standardisation and formalisation, which is typical of integration type, occurs at phase 1. Solving issues associated with standardisation and formalisation does not create barriers for more productive knowledge sharing through a heterogeneous network of experts, which is associated with collaborative type of knowledge work.

The urge to introduce standards and formalise processes starts with attempts to capture and codify existing knowledge (Davenport & Prusak, 1998; Hansen, Nohria, & Tierney, 1999), e.g. in a library of best practices, and had certain success (O'Dell & Grayson, 1998). However, it has led to the creation of useless document repositories all too often (McDermott, 1999). Thus, the model recognises the role of formalisation and standardisation, but also emphasises that it is only the beginning of the KM journey (phase 1). Most importantly, it draws boundaries between formalisation and standardisation, and KM.

Various forms of KM found in the case companies demonstrate how diverse this process is, and point at the limitations of technology in its facilitation of knowledge sharing (Li & Jhang-Li, 2010). Apart from document repositories knowledge sharing happens spontaneously through networks, characterised as informal sharing in the companies, and periodically within emerging communities. These are what Von Krogh (2011) identifies as two areas to understand knowledge sharing: agencies and communities. Thus, phase 2 of the model aligns with the literature. The agencies represent social capital (Inkpen & Tsang, 2005), which allows for mutual sporadic learning (Chow & Chan, 2008), and thus growing one's social capital or network of accumulated relationships helps to increase the potential for this type of knowledge sharing. Since it happens spontaneously (Wenger et al., 2011), common activities and spaces, so called metaphoric coffee rooms and coolers, are means of increasing networks (Davenport & Prusak, 1998) as the channels for this type of knowledge sharing (Clegg, Josserand, Mehra, & Pitsis, 2016), which is in line with what was particularly evident in companies 3, 4 and 5.

We have also observed the other type of knowledge sharing in communities that are formed through practicing similar work and by developing a shared identity (Von Krogh, 2011; Wenger, 1998). By engaging in more extended knowledge sharing and sensemaking (O'Mahony & Lakhani, 2011), members of a community learn from each other (Wenger et al., 2011). These characteristics help to understand why formalisation and standardisation become irrelevant at phase 3 of the model. Although networks can be supported with managerial interventions (Davenport & Prusak, 1998), of which formalisation would be an example, neither networks (Nahapiet & Ghoshal, 1998) nor communities (Pyrko et al., 2017) can be mandated. At the same time, from the model, managing explicit knowledge is indirectly connected to knowledge sharing, because it helps to free time for knowledge sharing from searching for articulated knowledge and repetitions, as was evidenced from the interviews. Similarly, knowledge sharing and creating new knowledge overlap and are related, because knowledge sharing builds the foundation for creating new knowledge.

Two issues worthy of further investigation were noticed in this research. The first issue, coming out of the principal study, was the suggestion that ideas management can be viewed as a KM practice. By engaging in ideas competitions, employees also engage in knowledge sharing and gain better visibility of work across the organisation. The second issue, also raised in the principal investigation, was the suggestion that innovation thinking might conflict with optimisation thinking. This is because innovation requires a company to be more tolerant of mistakes and accepting risk whereas continuous improvement and optimisation focuses on waste reduction, including the waste of time. We do not have suf-

ficient evidence to draw affirmative conclusions at this stage, but the raised issues suggest a possible direction for further research.

6. Conclusions

The developed KM model proposes a decision aid tool for innovative technology companies and makes them think about KM as a long-term project with clearly defined phases and a learning curve, rather than a one-time initiative. The specific KM practices that were identified for each phase of the model are specific to the type of companies under investigation. In other industries and types of organisational culture the KM journey will also consist of different phases, but the particular KM activities might be different. Some of them might overlap, e.g. some forms of knowledge sharing. Other activities, e.g. ideas management, might be not as critical as in innovative companies.

We acknowledge that amongst the studied companies we might have not observed the worst and the best cases. It is possible that the worst companies cannot recognise the value of our research yet, whereas the best ones do not see sufficient benefit to commit time to it. Therefore, the findings might be missing a step beyond what was observed. However, this limitation does not invalidate our findings, but rather builds avenues for further research. We are also mindful that this study is based on a limited sample, and therefore, we need to be careful with generalisation. In the narrowest sense, we can claim that the model works for the 6 case companies. These companies are characterised as innovative technology companies resembling adhocracy structure, and therefore, the findings are likely to be useful to companies with similar characteristics. In order to make a more conclusive claim about generalisability, a larger scale study would be necessary, where the representativeness of the sample is accounted for. However, this as an exploratory study, the purpose being to achieve the initial understanding of the phenomenon at hand.

This paper contributes to the body of literature by extending the existing KM frameworks of McIver et al. and Davenport. Adding a time dimension to these frameworks changes the perception of KM from a onetime initiative to being a continuous learning process. This model brings together different practices that were previously discussed in isolation, such as managing explicit knowledge and its limitations; knowledge sharing practices with the importance of networks and communities of practice in facilitating knowledge sharing; the aspects of lessons learnt with the importance of admitting mistakes and self-reflection as well as best practices; and finally, innovation being at the centre of KM. But rather than contrasting the practices, this model suggests that they complement and reinforce each other, and each of them becomes important at a certain point in time. For instance, the ideas contests can help to improve knowledge sharing, visibility of work or expand informal networks. However, if explicit knowledge is poorly managed, the potential for creating new knowledge might be limited.

These findings contribute to the academic literature by describing an evolutionary path of KM in the companies with particular characteristics, as opposed to suggesting a one-size-fits-all solution on a sort-term basis or discussing dominant practices in a particular industry without looking at the foundations that enabled these practices. In the phase of managing explicit knowledge the model acknowledges the importance of these practices and emphasises their limitations. In the phase of knowledge sharing the model puts knowledge sharing in a broader context and demonstrates the diversity of knowledge sharing practices that occur in an organisational environment. And in the phase of creating new knowledge the model presents how KM practices are intertwined with innovation management.

The major contribution of this research to practice is a KM process model, which can aid strategic decisions concerning KM. This model presents KM as a continuous effort rather than a one-off initiative, which results in a learning curve for an organisation, and thus it aims at changing the perception of practitioners on a KM project. The dynamic KM model consists of three interrelated phases and affects different aspects of the knowledge work, and therefore, it presents KM as a complex multidimensional phenomenon that has to be taken seriously.

The causal mapping method used in this study allowed for the exploration of a dynamic KM system, and further research might open up a wide array of application areas in the KM context. Any KM system involves agents and groups of agents, and such systems are inseparable from the effect of power, control and political aspects (Powell & Coyle, 2005). Qualitative influence diagrams (IDs), such as causal mapping, can be used as a dynamic diagnostic tool for such systems (Howick, Eden, Ackermann, & Williams, 2008; Shaw et al., 2017), e.g. understanding KM system (Powell & Mustafee, 2017) or mapping knowledge (Swart & Powell, 2006) in a specific organisation. The qualitative politicised ID (QPID) approach (Liddell & Powell, 2004), too, seems to be particularly suited to the analysis of knowledge dynamics, since it attaches agents/actors to causal links, thereby allowing examination of how their motivations can be affected by managerial intervention that alters system behaviour.

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