Towards Digital Transformation: Knowledge Management as an Enabler in a Public Sector Asset Lifecycle

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Abstract: Organisations often have visions of implementing advanced digital technologies, such as digital twins, regardless of whether the organisations are mature enough for these technologies. It is a common misconception that implementing advanced technologies will automatically lead to digital transformation and solve organisational challenges, such as disruptions in information flows or the inability to learn from recurring mistakes. The reality is, however, the contrary: emerging advanced technologies and digital transformation demand first and foremost reliable, high-quality data and the ability to use them. Therefore, organisations with inadequate information processes need to pay attention to their knowledge management (KM). In this paper, we demonstrate how KM is an enabler of digital transformation. A case study of a public sector asset lifecycle was conducted. Data were collected by interviewing 26 people representing the focal case organisation and its stakeholders. The results highlight the importance of organised KM for digital transformation. We identify enablers of digital transformation from the KM perspective.

1 INTRODUCTION

A public sector operation is a complex entity with many routines, stakeholders, and tasks. It has long been clear that to make an operation run smoothly, one needs to take into consideration the different stakeholders, their data sources, and their respective aspirations (Hellsten & Pekkola, 2020). It has been claimed that organisations need to evolve constantly (Osterwalder et al., 2020). Organisations sometimes aspire to implement advanced digital technologies despite the organisations' inadequate capabilities or their lack of the requisite maturity for these technologies. Similarly, it is common to hear that implementing advanced technologies can automatically solve organisational challenges, such as troubles in information flows, inaccessible information, outdated information, or recurring mistakes. Emerging technologies demand reliable and high-quality data to be beneficial (Davenport, 2014; Leonardi & Treem, 2020;). However, managing data quality is a problem for almost every organisation (Berson & Dubov, 2007). Knowledge management (KM) plays a significant role in data, information, and knowledge processing (Al-Emran et al., 2018). Therefore, organisations need to pay attention to their KM before implementing more advanced tools as a way of solving these challenges. In fact, KM has been integrated – at the conceptual level, at least – with digitalisation (e.g. Di Vaio et al., 2021).

We studied a public organisation's asset lifecycle. In our study, we found several barriers that hindered the full exploitation of the emerging tools in this complex lifecycle context. We demonstrate how KM is an enabler of digital transformation, that is, of significant organisational changes through combinations of information, computing, communication, and connectivity technologies (Vial, 2019). Well-organised and -executed information processes support and form a part of KM, which enables the information and knowledge built upon it to be used for organisational development (Choo, 2002).

Our objective in this research was to provide practical suggestions about enabling digital transformation from the KM perspective by recognising KM-related challenges that hinder the achievement of

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digital transformation and implementation of digital tools. We look at obstacles to attempts to achieve digital transformation. We enrich the practical findings with literature on the enablers of digital transformation. By combining the practical findings and literature review, we discover why digital transformation is so difficult and which practical steps can be taken to achieve such transformation.

Section 2 discusses the background of the study and related research in this area. Section 3 describes the case and the data collection. Section 4 presents the findings of our study, and Sections 5 and 6 discuss the issues and conclude our paper.

2 BACKGROUND

2.1 The IM Process as a Part of KM

Knowledge management refers to methods of understanding, defining, and utilising available knowledge and information that provides the users, i.e. the decision-makers, with useful tools for managing their organisations (Moss, 1999). It is an approach through which knowledge content in its various forms may be identified and put into use (Nonaka & Takeuchi, 1995). Knowledge is based on information and experiences.

Organisation and governance, identification of information needs, information acquisition, information organisation and storage, information products, information sharing, and information use form a continuous information management (IM) process (Choo, 2002). This process provides a framework for deriving knowledge and insights from data and information from organisations' own experiences and information sources, and it supports the use of information and knowledge in problem solving, decision-making, and strategic planning (Lake & Erwee, 2005). Information gets its final meaning and transforms into knowledge when it is used in decision-making, for instance, and changes in organisational activities take place. By adjusting operations and adapting behaviours, organisations create new information needs, and the cycle starts over.

Choo's (2002) process model of IM is one way to structure the knowledge process: knowledge is processed from data through information into knowledge. IM forms the backbone of efficient KM. However, to adopt such a model, an organisation needs not only the appropriate technical, structural, and cultural factors (cf. Gold et al., 2001) and the necessary processes in place but also the proper mindset for employees – attitudes combined with the skills to

make things happen (Jääskeläinen et al., 2022). IM has been criticised because of its limitations and narrowness in focusing only on data and information. IM's limitations become particularly clear when delivering tangible results in organisations (Kebede, 2010). This has led to an expansion of IM towards the management of tacit knowledge that occurs in the forms of, for example, experience, know-how, and competence, so that IM integrates a conception of KM (Kebede, 2010).

2.2 KM as an Enabler of Digital Transformation

Digital transformation refers to significant organisational change achieved through combinations of information, computing, communication, and connectivity technologies (Vial, 2019). The extent of digitalisation, success of its implementation, and realisation of its benefits depend strongly on the organisation's attitude towards renewals and readiness to participate in developing itself (Ding et al., 2014). Alvarenga et al. (2020) state that KM is a critical factor in the success of digital transformation in a public organisation. We use the IM process (Choo, 2002) as a framework for categorising the KM-related enablers of digital transformation.

Organisation and Governance. Bojesson and Fundin (2020) have identified five enablers of digital transformation: a sense of positivity, dedicated resources and commitment, cooperation and combined competences, lessons learned, and communication of visions and goals. Understanding the business strategy, the goal, behind the transformation is the first step of digital transformation (Upadrista, 2021). Resource allocation is emphasised in the literature. For example, Zhao et al. (2018) emphasise the importance of knowledge-based resource allocation for improving knowledge flows within networks. Data, information, and knowledge resources are key factors that determine an organisation's value creation potential (Kianto et al., 2014). Xie et al. (2016) point out that data, especially big data, are a primary driver of the digital era's changes. Mindsets and attitudes towards data, information, and knowledge must be changed to see them as valuable resources (Bojesson & Fundin, 2020; Myllärniemi et al., 2019).

Identifying Information Needs. Upadrista (2021) highlights the importance of understanding customers and their needs in the digitalisation journey. Hellsten and Myllärniemi (2019) claim that continuous feedback and active updating of information needs at all levels of operation, e.g. in customer relationship management, support KM activities, such as

processing qualitative information products and making knowledge processing more fluent; these processes also support digitalisation. Visibility and communication of information needs are crucial in digital transformation. Kretschmer and Khashabi (2020) point out the relevance of documenting organisations' information flows. Identifying organisations' information needs is a starting point for the development of knowledge processes but also guides the subsequent phases of the process (Choo, 2002; Myllärniemi et al., 2019).

Information Acquisition. Agrawal (2021) points out that knowledge capture and creation are essential enablers of KM implementation. According to Al-Emran et al. (2020), an individual's competence for acquiring knowledge affects their ability to adopt and use new technologies. As shown by Turulja and Bajgorić (2018), knowledge acquisition has a direct relationship with product and process innovation and with business performance. Al-Emran et al. (2020) have found that knowledge acquisition has a positive effect on perceived ease of use and usefulness. Digital services, as a concrete example of digitalisation, can offer value to customers and work as a channel for the acquisition of data and information (Frank et al., 2019).

Information Organisation and Storage. KM and related processes have an important role in the implementation of various information systems (ISs) (Al-Emran et al., 2018). Knowledge processes as well as their backbone, ISs, must be integrated with other processes within the organisation, as otherwise, daily operations, high-quality information, and information products do not create value for the decision-makers. (Myllärniemi et al., 2019). As information technology evolves further, the technological solutions approach the stage at which the features can feasibly be executed automatically, which not only streamlines actions but diminishes possible human errors (Tang et al., 2010).

Information Products. In the digital era, data and information offer organisations new ways to co-create value with their customers. Xie et al. (2016) have studied the transformation of digital resources, such as big data, into value assets, i.e. information products. This requires, for example, cooperative capabilities among customers and participating organisations (Xie et al., 2016). The outcomes of valuable and qualitative information products are remarkable. Upadrista (2021) summarises the significance of data by saying that data are the first thing to look at when making any business decisions.

Information Sharing. Individuals' readiness to share their implicit knowledge is a central prerequisite for prolific KM (Hislop, 2013). Individual capabilities, such as trust, motivation, and especially the enjoyment taken in helping each other, are KM enablers (Cavaliere, 2015). Information, and especially knowledge sharing, has a positive impact on the adoption and use of different information systems (Al-Emran et al., 2020). Tools that support information and knowledge sharing are relevant enablers of digital transformation (Al Nahyan et al., 2019). Al Nahyan et al. (2019) point out that holding regular and well-defined meetings to share relevant information and knowledge is essential.

Information Use. To ensure successful KM, it is essential that an organisation share its understanding of information and knowledge assets as highly valuable resources. Choo (2002) and Sergei et al. (2023) emphasise that managing the information process is an important enabler. This, of course, requires seamless cooperation among different stakeholders. As an example, Antunes and Pinheiro (2020) point out that an organisation's ability to use and leverage knowledge is dependent on its human resources and collaborative practices. Another example of cooperation between stakeholders is feedback. Bojesson and Fundin (2020) state that integrating feedback – and, more generally, lessons learned – into knowledge creation is an important enabler of digital transformation.

3 CASE DESCRIPTION AND DATA COLLECTION

Data were collected by interviewing 26 employees in 5 different organisations, as shown in Table 1 below. The focal case is a public infrastructure asset owner, i.e. a medium-sized city. The other four organisations cooperate with the focal case in shared projects, forming a project network with an asset lifecycle. Organisation D is a public organisation, and the others are private companies. As illustrated in Table 1 below, the case organisation manages its assets for the whole lifecycle – from design to construction and maintenance. Maintenance may take place for centuries in old cities in which streets are redesigned, reconstructed, and continuously maintained. The actual design and construction are carried out by consultancies and contractors, who were included in the interviews (Organisations A–C) to gain more a holistic view of the IM process of the case. Maintenance of assets, on the other hand, is a mixture of outsourced and in-

Table 1: Interviewees by organisation.

Organisation	Work description	Inter-viewees
Case organisation	Project managers in design	3
Case organisation	Project managers in construction	5
Case organisation	Maintenance management	3
Case organisation	Management	2
Case organisation	IT administration	3
Partner A	Site managers in construction	2
Partner B	Design engineers	2
Partner B	Site managers in construction	2
Partner C	Site managers in construction	2
Partner D	Project managers in design	2

house maintenance, but only the in-house maintenance staff was interviewed due to accessibility issues. In addition, the focal case organisation practices interdependent cooperation with another asset owner in the design phase (Organisation D). The focal organisation makes for an interesting case, as they have a vision of implementing collaborative BIM (building information modelling) and dig-ital twins in the asset lifecycle to make their work easier. They wish for the information models and digital twins to be constantly updated through the asset lifecycle. While digitalisation may mean digitising existing tools, digital transformation includes the wider business process changes that implementing these technologies for the whole lifecycle would require. Both technologies are dependent on high-quality data (Gould, 2010; Moretti et al., 2022). However, previous research (e.g., Eastman et al., 2011; Siuko et al., 2022) has found that

organisations in the infrastructure construction sector struggle with the organisational processes that must be in place for the successful implementation of advanced digital tools.

The semi-structured interviews had three themes: everyday work, current IM in everyday work, and ideal IM in everyday work. Following the suggestion of Galletta (2013), the first theme had two goals: establishing a level of comfort and creating an understanding of the interviewee's perspective, Therefore, the interviewees were asked about their work, their work routines, and decisions they make during work. The goal of the second theme was to link their everyday experiences to our research questions (Galletta, 2013). For example, by asking how the interviewee knows what they should do and when, and where they get the information they need, we could map the information and KM processes. The last theme concentrated on an ideal future scenario, and we tried to make the interviewees think about solving the challenges that came up during the second theme.

The data were analysed using thematic analysis and coding. First, the transcribed interviews were browsed to obtain a holistic view of the data, and the data were then coded iteratively with Atlas.ti; finally, the codes were grouped into predetermined themes, following the suggestions of Clarke and Braun (2017) and Grbich (2013). The predetermined themes were chosen based on the IM and KM processes (Choo 2002). Finally, the data were linked to digital transformations through collaborative BIM.

4 FINDINGS

Collaborative BIM was seen as a solution to information-related challenges. IT management and maintenance management staff from the chosen organisation and a design engineer from Organisation B agreed that shared information models would ease their work. However, the design engineer added that
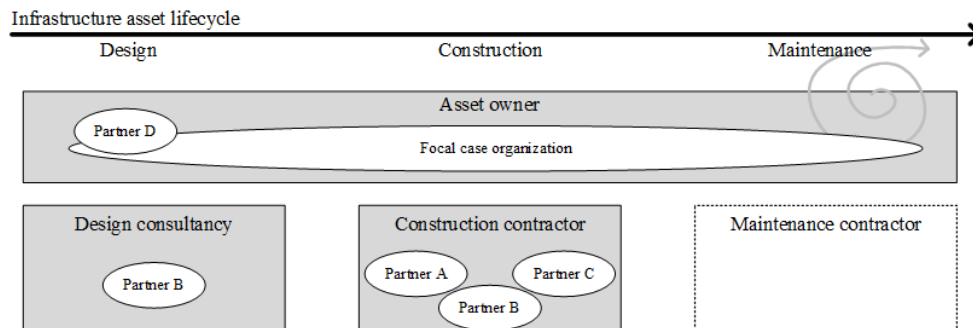

Figure 1: Chosen organizations in the infrastructure asset lifecycle.

gaining access to common information systems would make a difference. In addition to having collaborative BIM, the case organisation management team wished for a digital twin.

The project managers from the main organisation were the only group that raised concerns about the expenses of collaborative BIM. According to them, mistakes made in design are more expensive to rectify when linked to information models. On the other hand, a site manager from Organisation A suggested that information models could reveal design mistakes before construction, which saves money in the construction phase. Overall, the empirical findings revealed multiple barriers to collaborative BIM.

According to a construction manager and a design project manager from the focal organisation, resources were limited, affecting the quality of the work, including the quality of the information produced. It was also mentioned that tasks emerged that were not their responsibility, and according to a site manager from Organisation B, the project guidelines were inadequate. Therefore, it seems that the roles and responsibilities were undefined. A site manager in Organisation A suggested that when the roles and responsibilities were better defined in their organisation, human resources could be better allocated and the amount of unnecessary or duplicated work would decrease. The management team from the focal case organisation also identified that a lack of resources makes implementing new information systems and policies challenging.

Both management and IT management from the focal organisation raised concerns about collecting indispensable information and not concentrating on valuable information. According to the IT management, valuable information had not been identified when their information systems were built. They also stated that the instructions for collecting the information and the form in which it was to be collected were unspecified. The management admitted that the organisation's information needs were not communicated well enough to their partners that collect the information. A design project manager in the focal case organisation wondered which information they should provide to their partners, and a site manager in Organisation B stated that they did not know precisely what information was needed from them, which indicates that the lack of awareness of information needs goes both ways.

A design project manager from Organisation D stated that managing materials, documents, and data manually is too burdensome. They desired machine-readable codes that enable automatic, systematic, fast, and reliable information collection. A site manager from Organisation C added that information was sometimes unreliable since the information acquisition tools were dependent on internet access. According to a site manager from Organisation B, the focal organisation wanted to collect information repeatedly for it to be compatible with their information system. The maintenance management added that some information would get lost in the previous stages, so they would need to collect the same information again.

The challenges with repetitive information acquisition were related to challenges with information organisation and storage, which could lead to outdated, missing, and unreliable data. The information was unorganised, and there were inadequate information storage practices. Thus, information was hard to find, and the information stored was forgotten and never updated, according to the responses of IT and design project managers from the focal organisation. The latter added that the collected information occasionally would not be stored. Management from the focal organisation had noticed that the information stored was uncoordinated, as they would get different outcomes from different systems for the same requests. This might also be due to the lack of interfaces, as a maintenance manager pointed out.

A site manager from Organisation B mentioned that the information was shared via various channels, and the information received might not be what was requested. The maintenance management in the focal organisation reported their inability to give feedback on designs, as they would receive the design documents too late and thus could suggest changes. On the other hand, design engineers from Organisation B wished for more feedback on their designs – which were successful, which were not, and why. Also, a site manager from Organisation C expressed a wish for more feedback, as they felt that they had no way of knowing whether the main organisation was satisfied.

Site managers from Organisations A, B, and C reported that information products created by design are unreliable, are incompatible, and create additional costs in the construction phase. They suggested that site visits should be made and designs checked before construction to make sure that they do not overlap with each other, are consistent, and are possible to construct on-site.

Finally, when it comes to information use, the information needed might not be available. A site manager from Organisation B reported that they might not have received requested documents when the construction was supposed to start, and they did not have access to customers' asset information systems to check the documents.

5 DISCUSSION

This research and the related literature (e.g. Davenport, 2014; Eastman et al., 2011; Leonardi & Treem, 2020) show that changes in organisational processes are needed to enable digital transformation. We now discuss why the implementation of digital tools is difficult and how a digital transformation can be enabled.

The focal case organisation had challenges with information and knowledge-related processes. They had a vision of addressing these challenges with more advanced digital tools and a digital transformation. According to Upadrista (2021), the first step of digital transformation is to link it it to the business strategy and business objectives. Bojesson and Fundin (2020) support this idea and emphasise the importance of communicating the vision and goals to stakeholders. **In other words, the first step is to identify the needs behind digital transformation and communicate them to the organisation and stakeholders.**

Our findings show that not enough resources are allocated to data and information quality, which then affects the quality of information products. Under-resourced implementation of new digital tools and organisational changes will fail, our findings indicate. It seems that allocating too few resources to information and knowledge management is caused by not recognising the value of information and knowledge. This claim is widely supported by other researchers (e.g. Bojesson & Fundin, 2020; Myllärniemi et al., 2019; Upadrista, 2021). Dedicated resources and commitment are important for information and knowledge to flow in an organisation (Bojesson and Fundin, 2020; Kianto et al., 2014; Zhao et al., 2018). Quality data are a primary driver of digital changes and enabler of the successful implementation of advanced digital tools (Gould, 2010; Moretti et al., 2022; Xie et al., 2016). Cooperation is another enabler (Bojesson & Fundin, 2020), which cannot be achieved without defining roles and responsibilities: not knowing who should do what results in redundant work. **Dedicating resources and delegating key responsibilities to each actor is essential for organising and governing digital transformation. Data, information, and knowledge need to be acknowledged as valuable resources.**

Documenting information flows and continuously updating information needs is essential for establishing successful knowledge processes (Choo, 2002; Hellsten & Myllärniemi, 2019; Myllärniemi et al., 2019; Kretschmer & Khashabi, 2020). Our findings support the literature in this regard. The focal organisation had not identified and communicated their information needs, which makes information acquisition, storage, and sharing difficult. Upadrista (2021) highlights the importance of understanding the customer's needs. If stakeholders do not identify information needs, they will be unable to deliver the required information. In the case studied, the customer organisation had decided to collect the needed information themselves rather than requesting it from the contractor to make sure that the information was compatible with their systems. We suggest that digital transformation is more easily achieved if there is a shared awareness of all stakeholders' information needs. **In other words, if information gaps hinder digital transformation, the organisation must learn to identify the information needs of key actors. In addition, the information needs must be communicated clearly throughout the lifecycle.**

Information acquisition practices and tools have a notable effect on business performance (Agrawal, 2021; Turulja & Bajgorić, 2020), as also demonstrated by our findings. We show that, when acquiring data and documents requires too much manual effort or the tools are inadequate, the result is unavailable or unreliable data and lost information. Frank et al. (2019) suggest that digital tools and services support information acquisition. **Thus, if an organisation struggles with information being unreliable and must constantly reacquire it, we suggest investing in data acquisition tools.**

KM, information systems, and daily operations have an important link to one another (e.g. Al-Emran et al., 2018; Myllärniemi et al., 2019). If one fails, the others are affected. Even when daily operations are automated and human effort is decreased, the importance of human-executed operations and KM does not decrease (Tang et al., 2010). Our findings show that it is difficult to keep data accessible, reliable, and updated with insufficient interfaces and inadequate data- and information-storing practices. **Therefore, we suggest that reaching the full potential of existing information systems is more likely after implementing interfaces and making sure that information organisation practices are well organised and communicated.**

Analysing data and processing them into usable information products and services enables better decision-making (Upadrista, 2021). Our findings show that unreliable data lead to unreliable information products. In our case, this means unreliable design documents for construction. The interviewees suggested double-checking information products and data reliability before distributing the information

products. Xie et al. (2016) add that cooperation between stakeholders is also required. In sum, information products can only be as reliable as the data on which they are based **To improve the quality of information products, the first priorities are to improve data and information storing and organisation practices, information acquisition tools, and the ability to identify the information needs behind information products in cooperation with stakeholders.**

KM is dependent on individuals being willing to share, acquire, and store data, information, and knowledge (Al-Emran et al., 2020; Cavaliere, 2015; Hislop, 2013). Networking is an important part of digital transformation, which makes information and knowledge sharing essential (Al-Nahyan et al., 2019). Our findings support the idea that even if the organisation studied had defined an ideal information and knowledge management process and implemented the most advanced tools, the actual benefit could be lost if people are not willing to share the information and knowledge they possess. Information and knowledge sharing should be encouraged through regular and topical meetings (Al Nahyan et al., 2019). Feedback and knowledge creation from past mistakes enable learning and change (Bojesson & Fundin, 2020; Choo, 2002). It was also clear in our findings that e.g. improving the quality of information products is very difficult without feedback. **To enable digital transformation, it is essential to ensure the willingness to share information and ability to learn from mistakes and to create new knowledge through constant feedback.**

In conclusion, we suggest several KM-related enablers of digital transformation, which are bolded in this section. With these enablers, we want to highlight that achieving digital transformation is not only about implementing new technologies.

6 CONCLUSIONS

The aim of this paper was to research which KM-related challenges can hinder digital transformation and to provide suggestions on enabling digital transformation from the KM perspective. Our case study in the public sector asset lifecycle provided an opportunity to study digital transformation empirically in an organisation that prioritises technological solutions over practices and processes, which is our contribution to the theoretical community.

For the practical community, we aimed to provide enablers that can be practically implemented. Our suggestions may help organisations advance digital

transformation in their asset lifecycles. Our study supports the finding of previous literature (e.g. Davenport, 2014; Eastman et al., 2011; Leonardi & Treem, 2020) that digital transformation requires widespread changes in organisational processes. We recommend more research on digital transformation in a lifecycle setting in both the public and private sectors.

According to Yin (2003), a case study's quality is evaluated based on its construct validity, external validity, and reliability. As an effort to ensure construct validity and include multiple sources of evidence, we interviewed partner organisations in addition to the focal organisation. We also presented our findings to a representative of the focal organisation and another from a partner organisation. To enhance the external validity, we complemented our findings with the existing literature in the discussion section. Finally, regarding reliability, we have described our data collection procedures and introduced the organisation studied as an exemplary case.

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