Knowledge transfer from building operation to construction.

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ABSTRACT

Purpose: To investigate how knowledge that derives from operation and maintenance of buildings can be stored and transferred in order to be reused in a future building project?

Design/methodology/approach: The paper is theoretically based on knowledge management with a particular focus on interdepartmental knowledge transfer between departments responsible for operation and management and departments responsible for building projects in organisations with large and fast changing building portfolios. The paper includes a case study of the FM organisation of the Technical University of Denmark with data collection mainly by interviews with managers and staff in the relevant departments in this organisation.

Findings: The case organisation seems to be aware of the importance of sharing and transferring their organisational knowledge. Over the last five years, the organisation has developed different tools and adopted several processes, aiming to the integration of the knowledge they possess from many years of operation and maintenance of the existing buildings. However, there are many situations, where the tools and processes do not work efficiently, and therefore the knowledge transfer is not sufficiently effective. It is apparent that the best results can be achieved only if the different actors involved in a construction project collaborate aiming towards the same objectives.

Originality/value: The paper presents and evaluates a case of interdepartmental knowledge transfer in an organisation, which has a strong focus on improving the interconnections between building operation and planning new building projects.

Keywords: Building Operation, Knowledge Management, Project Management, Construction projects, University Campus

1 INTRODUCTION

This paper concerns a challenging topic within the construction industry and the Knowledge Management (KM) discipline. The issue that is examined is knowledge transfer (KT) between building operation and project management of construction projects to ensure appropriate performance of new facilities.

According to literature, the involvement of Facilities Management (FM) expertise in a construction project from its early phases is of great importance (Jaunzens et al., 2001; Jensen, 2009; Hansen et al., 2010; Meng, 2013). Although it might be assumed that knowledge transfer could be approached in the same way as it is in other kind of industries, the nature of the construction industry makes it difficult. Construction firms move from one building project to another, which usually differs substantially from the previous one. The lack of distinct similarities between these
building projects makes the project management team more reluctant to consider, extract and reuse knowledge that has been acquired during past projects.

The purpose of the paper is to answer the following research question: How knowledge that derives from operation and maintenance (O&M) of buildings can be stored and transferred in order to be used in a future building project? Besides, the paper aims to clarify the benefits that occur from this, the barriers that are preventing KT between these two parties, as well as the KS and KT tools and processes that have been developed and are being used within the organisation.

The paper is based on a case study of the FM organisation of the Technical University of Denmark (DTU) called DTU Campus Service (CAS). They are in charge of management, operation and development of all the existing facilities of the university as well as a huge construction program of new buildings at its main campus, following a number of fusions with former independent institutions. The case study examines the intradepartmental knowledge sharing (KS) in, as well as the interdepartmental KT between, the building O&M department and the department responsible for new construction projects – the Real Estate Project Management Office (PMO). The methodology of the study is described in section 2 followed by a literature review on KM in section 3. The case study is presented in section 4 and followed by discussion and recommendations in section 5 and conclusion in section 6.

2 METHODOLOGY

CAS was chosen for the case study, because they are one of the largest building clients in Denmark at the moment, they have a large in-house departments responsible for O&M of buildings, and earlier research (Rasmussen et al., 2014) has shown that CAS as an organisation is deliberately aiming at increasing knowledge transfer from building operation to building projects. The methodological approach used during the research was divided into three stages.

In the first stage a broad literature review was conducted sub-divided into two parts. Initially the field of KM was examined thoroughly, giving weight to the aspects that are useful and assist the understanding of the importance of KM within an organisation. Secondly, research regarding KS and KT in construction industry and particularly in KT between FM and building design was conducted.

The second stage focused on data collection, using semi-structured interviews, which took place during spring 2015. As the research is qualitative, interviews were considered to be the most suitable method of data collection. Ten interviews were conducted. Two of these were external experts, while the remaining eight were with people from CAS, see the case study section below.

The third stage included analysis and categorization of the data that were gathered during the interviews. The categories in which the data were placed were regarding the KS and KT behaviour and activities that CAS uses at the moment and were used in the past as well as KS and KT activities that are being developed at the moment to be used in the future.

3 LITERATURE REVIEW

KM is a relatively new management field, established on the argument that it is a challenging task for an organisation to fully utilize the knowledge that they create or possess. The information technology revolution is one of the crucial reasons, why increased access to knowledge has become
possible. It is of great importance to discriminate between data, information and knowledge. A collection of data is not information, and a collection of information is not knowledge. Therefore, KM can be described as the strategy that aims at development of organisational knowledge through accumulation of data and information, along with past experience derived from the human resources (Dubey and Kalwale, 2010).

A common way to distinguish knowledge is into two fundamentally different categories; explicit and tacit. The explicit knowledge is useful technical knowledge, which comes from the employees and can be explained by them; thus can easily be codified. Once codified and stored, this explicit knowledge can be distributed within the organisation and reused. Examples of explicit knowledge are templates, patents, reports and copyrights. Tacit knowledge is non-articulated knowledge and thus inherently personal, which makes it difficult to be extracted out of human minds, formalized and disclosed in manuals in order to be shared or transferred. Another difference compared to explicit knowledge is that tacit knowledge consists of a technical and a cognitive dimension. While explicit knowledge has a solely technical dimension, tacit includes individual experience along with personal belief, perspective and values. This feature constitutes an obstacle to the transferability of tacit knowledge (Lundvall, 2004).

Knowledge codification is an important part of the knowledge refinement process, which includes the techniques that extract, filter, clean and reform the new knowledge in order to enter the various knowledge repositories. Such repositories hold both organisational knowledge and information, either in an electronic form (i.e. knowledge databases), or in a documented form (Davenport et al., 1998).

Technology has a crucial role in the acquirement and codification of organisational knowledge as it can store large amounts of knowledge, allowing its smooth distribution and re-use. Therefore, a robust Information and Communication Technology (ICT) infrastructure to support both the codification and storage of the organisational knowledge is necessary. The selection of appropriate technology should be aligned with different organisational aspects. The most important aspect is organisational culture as it is the one that affects internal communication and KS, with operational, technical and cost aspects being significant as well (Smith, 2001).

In order for knowledge to be spread and affect the organisation, it has to be either transferred or shared. In KT, knowledge is communicated from a sender to a known receiver, having a specific focus and purpose (King, 2009). On the other hand, in KS knowledge is exchanged among individuals, groups or organisational units and usually does not serve any specific purposes, thus it can be either focused or not (Paulin and Suneson, 2012). Therefore, in this paper KS refers to knowledge that is shared between the participants of the same group, network or organisational unit, while KT refers to knowledge that is transferred from a group, a network or an organisational unit, to another.

The success of KS is heavily based on the existence of cooperative behaviour between the participants. Appel-Meulenbroek (2014) distinguished cooperative behaviour into two main types; interaction and collaboration. Interaction adds structure to how departments interrelate and describes a more formal kind of cooperation with routine activities, such as scheduled meetings and teleconferences, routine calls or standardized documentation. On the other hand, collaboration represents the unstructured, affective nature of intradepartmental relationships portrayed by more informal processes and mutual understanding between the different parties which work together sharing a common vision and a same objective.
KT mechanisms are currently a hot topic in the KM field (Zuo et al., 2013). The initiation mechanisms of KT can be categorized into push, pull and fixed (or symmetric) mechanisms. Knowledge push represents an initiation mechanism where the sender provides knowledge without any particular demand for it, knowledge pull is a mechanism where the receiver is the one that requests the knowledge, while a fixed KT initiation mechanism depicts the scheduled KT activities, such as regular meetings, where both sender and receiver play an active role through established interaction activities (Ahmed-Kristensen and Vianello, 2015). Another type of categorization of the KT mechanisms, in respect to the strategies for capturing and transferring knowledge, is the distinction between personalization or codification strategies (Lê, 2007; Jensen, 2012; Ahmed-Kristensen and Vianello, 2015). The personalization strategies represent a more informal communication between the participants and can be related to the collaboration KS activities. Usually through these strategies new knowledge is generated and existing tacit knowledge becomes available to the receiver. On the other hand, the codification strategies refer to the transfer of the explicit knowledge that is captured into knowledge repositories, related more to the interaction activities.

4 CASE STUDY

The main purpose of DTU CAS is to ensure that all students and personnel are provided with the best possible physical working conditions in all DTU’s 17 different locations around Denmark and Greenland. CAS is headed by a campus director with reference to the university director and is subdivided into three different departments, each headed by a director, see Figure i.

These departments represent the core activity areas of the organisation; Real Estate PMO, Facilities Maintenance and Projects (O&M), and Real Estate and Space Management. The organisation is physically distributed on 6 locations, employs approximately 180 employees and has its headquarters at the main campus in Lyngby, north of Copenhagen. The case study concerns the main campus, owned by DTU, as it is currently expanding in order to support the centralisation...
of the external research institutions, currently placed in rented buildings elsewhere, as well as the future demands deriving from the increase of students and staff.

The eight interviewees from CAS included the heads of the three departments as well as section leaders and project managers from the O&M and PMO departments, whose interaction was examined.

4.1 KM in CAS generally

According to the literature review interaction as a cooperative behaviour for KM is more structured and formal than collaboration. Interaction in CAS is established on a phase-gate model that has been developed based on the principles of PRINCE2 project management model in order to support every new construction project, in which all the departments of CAS along with external actors, are involved. A building project in CAS is divided into four main stages; Conceive, Design, Implement, and Operate (CDIO). Each of these stages is subdivided into different phases, representing the activities that take place during the project execution. All CAS departments are involved in a building project, depending on the phase that the project is in. Each phase is followed by a gate-point, where activities that support the interaction of the involved in the project parties, occur. These activities are usually scheduled meetings or exchange of documented information for review or approval from CAS units or other project participants.

Collaboration as a type of cooperative behaviour for KM includes unstructured and informal organisational processes, as mentioned above. Although CAS has a structured cooperative behaviour in terms of interaction, when it comes to collaboration, they have not yet achieved an adequate level within the whole organisation. A clear common goal regarding KS has not been defined. Employees in CAS know that they have to share knowledge between them and transfer knowledge to another department when necessary, but there has not been formally stated a strategy that clarifies, why and how it should be done. On the other hand, the heads of CAS departments collaborate to a higher degree than their employees do. At the moment the three departments are placed in three different buildings at the campus, which in many cases may result in the development of subcultures within the organisation. Even though subcultures can be considered as a positive consequence, because employees feel as a part of a community and therefore may collaborate and perform better, it can prevent the development of a common organisational culture. However a new building is constructed in order to gather CAS departments during 2016, aiming as well to the development of a strong universal organisational culture.

As mentioned in the literature review, KM depends heavily on ICT-based tools. Since CAS is moving to a direction where the knowledge that has arisen from previous projects will be shared in order to be reused, they invest in ICT systems to assure competent and efficient KS throughout the organisation. Two such systems are the Building Information Modelling (BIM) for 3D models of buildings and a Computer-Aided FM (CAFM) system, which will be used among other things for maintenance management. However, both systems are not fully developed and updated with data of all buildings and projects yet.

4.2 KT from O&M to PMO

The main activities in O&M are the amendment of the faults that are reported through a helpdesk system, and the management of planned maintenance projects. However, its responsibilities include also the transfer of the knowledge created during building operation and maintenance to PMO, assisting this way the reuse of this knowledge by the project managers during their projects.
DTU’s main campus has a distinctive architecture that it is important to preserve. One of the main focuses of O&M is the conservation of the campus architectural harmony as well as the avoidance of having buildings that is difficult or expensive to maintain. However, sometimes external architects in order to leave their footprints by designing a building that will differentiate from the existing, tend to ignore the original architecture and the general aesthetics of the buildings. Hence, it is essential for O&M to set some requirements, by using their knowledge from operation and maintenance of existing buildings, and transfer it into the new projects.

The type of KT from O&M to PMO can be described both as knowledge push and as knowledge pull depending on the phase of the project. During the first meetings in the design brief phase of a project, O&M section leaders ‘push’ knowledge, through the design specifications that they pass on to the project team, setting in this way the requirements that assure the efficient future maintenance and the preservation of the original DTU architecture. On the other hand, PMO project managers call meetings with O&M section leaders and try to involve them in every project phase, in order to ‘pull’ knowledge useful for the project, through the O&M section leaders’ feedback.

A critical issue that has an impact on several KT activities of O&M is the lack of human resources. The main responsibility of the O&M section leaders is to coordinate basic operation and maintenance activities and define the new maintenance projects they are in charge of, with respect to the future needs of the buildings. Additionally, after each phase of a PMO project, they have as an extra duty to participate in meetings with the project managers and provide the project team with feedback by commenting on project drawings and documents. These tasks are time-consuming processes and sometimes O&M section leaders cannot attend the meetings or give feedback on the projects on time. In order to improve the efficiency of the O&M sections and support the O&M section leaders, CAS employed extra personnel over the last years.

A rather new method that O&M has started to use extensively in the recent past, in order to assist the KT from their department, is codification of their departmental knowledge. This codification is based on production of documents that standardize specifications or solutions and are applicable in both new construction and refurbishment projects. The main standardization method used by CAS is the development of design standards. The development of these standards started on the request of a PMO project manager, who wanted to simplify the facilitation of KT from O&M. They define the design requirements that have been set by O&M, having as main parameters design consistency, level of complexity and cost of maintenance. For instance, a toilet standard aims to prevent designing different toilets around the campus, while saving time during design.

The standards are distributed to the project team by the O&M section leaders in the design brief phase of each project; thus, the KT through the design standards can be described as knowledge push as shown in Figure ii.

![Figure ii KT from O&M to PMO through design standards](image-url)
From this moment the responsibility regarding their implementation on the design of the project passes to the project managers. However, often O&M section leaders discover that the decisions that have been made during the project phases are not compatible with the standards’ requirements. This can happen either because the requirements set in the standards could not be applied to the specific project or because the project team disagrees with them. In this instance, O&M section leaders need to remind the project team about the implementation of the standards or, in case of disagreement, try to find a common ground.

4.3 KT from PMO to O&M

PMO is in charge of all the new building projects of DTU. The project managers in PMO comprehend fully that after the completion of a project, O&M personnel will inherit and be responsible for the operation and maintenance of the building; therefore the O&M personnel needs to be familiar with the building and know how its technical systems function. The head of PMO uses what he calls the “gift metaphor”, where the new building is seen as a gift that PMO is wrapping up in order to give it to O&M. When the people in the latter department unwraps the gift, they should be able to use it; hence PMO should provide them with all the necessary knowledge and instructions. To achieve this, PMO uses processes which facilitate transfer of the knowledge that is created during the different project phases. The knowledge that arises from PMO and could be beneficial for O&M is mainly associated with new processes, technologies or materials that can substitute the currently used. Usually, project managers try to push this knowledge to the O&M section leaders, during their meetings after each project phase.

However, according to the interviewed O&M section leaders, KT from the PMO project managers is not an often occurring phenomenon; thus the knowledge distribution can be characterized as asymmetric. Moreover, the knowledge that is transferred is not always considered relevant or useful for the O&M section leaders because these two participants “look at the project with different eyes”. The O&M section leaders are more concerned about buildings which maintenance does not require too much effort and expenses, while the project managers are more focused on delivering an original, innovative and less conventional building, ignoring the future maintenance difficulties. Therefore, most of the times the knowledge that PMO tries to transfer to O&M, is not being used.

The time that O&M usually devotes to KT activities is limited due to their lack of human resources. Hence, KT from PMO to O&M can be described as knowledge push, supported by the use of ICT-based systems. Project managers push the information and knowledge that arise during a project into the ICT-based systems that serve as knowledge repositories – including a project-web called iBinder. Following, it depends on the availability of the O&M section leaders to pull and use this knowledge, as shown in Figure iii. The same knowledge push from the project managers is happening also during their meetings with O&M section leaders after each project phase. There, the project managers are ‘pushing’ information and knowledge regarding the project to the FM section leaders, requesting their comments.

On the other hand, project managers in PMO are also engaged with tasks related to their projects, thus sometimes their work overload does not allow them to hold discussions and give feedback to the comments that they receive from both O&M section leaders and user groups. Therefore, some of the decisions are not made in common and this can cause tensions or disappointment between the participants.
5 DISCUSSION AND RECOMMENDATIONS

The discussion and recommendations in this section are structured according to a management tool called POKI – Process, Organisation, Knowledge and tools, and Information and communication (Due and Stephensen, 2011), which was developed as part of a project about best practice in implementation of FM knowledge in construction projects. It aims to assist an organisation in overcoming the usual barriers that are met during the integration of FM expertise into new construction projects.

5.1 Process

This POKI element concerns the revolving process of a construction project divided in phases, from feasibility study to handover of the finish building. The phase-gate model that CAS has developed is being used in every construction project and is enriched with interaction activities, so that O&M, end users and other important stakeholders will be involved in the project from its early beginning. This model seems to be best applicable to large and complicated building projects, but for smaller and not so complicated projects it appears less suitable. Therefore, the development of simpler versions of the model is recommended, so that it is decided before the beginning of a new project, whether a simple, medium or comprehensive model should be applied.

A critical parameter in the ‘process’ element is the assurance that all project participants are aware of the common goal of achieving a user- and FM-friendly building. The interviews revealed that the PMO department is gradually becoming more aware of this parameter. For instance, the “gift metaphor”, that the head of PMO used, shows how important is for him the development of FM-friendly buildings that fulfil the O&M and user requirements. However, part of the project managers in the PMO department and all the specialists, that constitute the project teams, are external consultants; thus, they do not feel part of the organisational culture and they do not hold responsibility after the delivery of a building project.

5.2 Organisation

The ‘organisation’ element of the POKI management tool underlines the importance of including the right persons into the KT processes. The involvement of representatives of future users, FM personnel and technical consultants is considered to be essential. As described in the previous section, CAS involves all these actors in its construction projects through the phase-gate model. However, during the interviews the heads of the departments of CAS seemed to doubt the personnel’s competences regarding using the existing ICT-based tools that assist the facilitation of KT between and within its departments. A suggestion that could help CAS to improve personnel’s skills and ensure that everyone involved in the KT is competent enough to work effectively with the existing tools, is to provide them with the appropriate training.
5.3 Knowledge and tools

As described in the previous section, over the last years CAS has developed – and is still developing – various ICT-based tools. Even though the amount of the existing tools and techniques might be sufficient, their effectiveness is often in dispute. The ICT systems are not fully developed and updated, which means that they cannot fulfil their role as knowledge repositories. Therefore, it is suggested that the O&M department assign a small group (2-3 employees) of each O&M section for a short period of time, which after being trained can fulfil this task.

Another tool that could be adopted by CAS is checklists that will assure that the most critical demands for each project phase have been satisfied. Maintenance checklists have been developed and have been more popular over the last years within the construction industry. For instance, during their study, Hassanain et al. (2015; 2016) developed maintainability design review checklists about electrical and water supply and drainage systems for campus maintenance departments in universities in Saudi Arabia. These checklists were developed to be used by design teams in order to reduce the occurrence of the most frequent defects.

A third tool, that could benefit CAS, is Life Cycle Costing (LCC) – also called Whole Life Costing (ISO, 2002). LCC is a tool which provides economical overview of a building over its lifetime, including both initial investments in the construction project and ongoing expenditures to building operation etc., helping to achieve the right balance between investments and operational expenses.

5.4 Information and communication

The establishment of an effective KM strategy (KMS) can assist an organisation in order to benefit as much as possible from the existing organisational knowledge. However, usually the management of an FM organisation does not realize the necessity of forming a KMS. In CAS, even though there is no established KMS, some of the interviewees have noticed a change in the organisational culture regarding KS over the last years. In an organisation like CAS, where both construction projects and FM activities take place, two different mind-sets are met; ‘hunters’ and ‘farmers’. According to Johnstone et al. (2007), a hunter’s mind-set is orientated towards the successful development and execution of high-profile projects within the provided time frame. In CAS this mind-set describes the PMO project managers, as according to the heads of the departments they are described as ‘butterflies’ that after the completion of a project fly away to the next one. On the other hand, a farmer’s mind-set represents a long-term focus, where continuous improvement and benefit through sharing knowledge deriving from past experience, are main goals. This mind-set can be linked to the O&M department’s mind-set, as they are more concerned about the operation of the facilities in long-term.

The co-existence of these two kinds of mind-sets within an organisation and the development of a common KS-oriented culture is not dependent on the replacement of the hunters’ mind-set with a farmers’ mind-set. The most effective way to combine them both in the same organisational culture is to find a balance between them. The development of a KMS can assist this effort and therefore can assist the development of a common organisational KS culture. An effective KMS is tailored to a specific context of use; hence, it should be able to answer the questions ‘What knowledge to share?’, ‘Whom to share with?’, ‘Why should knowledge be shared?’ and ‘How will knowledge be shared?’ In the case of CAS, the CLEVER (Cross-sectoral Learning in the Virtual Enterprise) framework, which was developed to support the establishment of a KMS addressing a specific KM issue within an organisation (Anumba et al., 2005), is suggested to be applied.
Besides, it is essential to develop an organisational culture, which is built on mutual trust among the participants and is based on collaboration processes. The two different units of CAS, which have been analysed in this paper, need to develop a more holistic point of view, without focusing exclusively on their own success. The establishment of an organisational culture in CAS could include the use of incentive systems that will keep the staff motivated. The development of a KT incentive system within an organisation is a rather tough process, as it usually involves the study of the factors that motivate the participants to share or transfer the organisational knowledge. Pemsel and Blomé (2011) conducted a research on real estate organisations in Sweden, which tried to identify what motivates the employees in the construction industry to perform successfully in their job, and proposed appropriate incentive systems. Their study revealed that the two fundamental motives of the employees are their eagerness to develop a construction project that will satisfy the client, and to undertake more challenging projects. What is interesting in this study is that the employees are seldom motivated by improving their relationships with their colleagues or their consultants, while a possible increase of their salary does not constitute a motive at all. It is suggested that CAS follow a similar procedure by first identifying the motives of the main participants in the KT activities, and then develop suitable incentive systems.

6 CONCLUSION

This paper aimed to examine the knowledge transfer from building operations units to the construction project management in FM organisations to ensure appropriate performance of new facilities. The type of knowledge that has been examined, derives from the O&M of existing buildings and is either shared or transferred. According to the literature, the involvement of FM in a construction project from its early phases is crucial. In a new construction project FM units can provide the project team in charge, with valuable knowledge that supports the decision-making, ensuring that decisions with long-term benefits are made. For the facilitation of this knowledge transfer from the FM units to the project team, several tools and frameworks have been developed. ICT-based tools, such as intranet, project-webs, BIM and CAFM systems, play a key role in the facilitation of this knowledge transfer. However, these systems just serve as knowledge repositories that can store huge amount of data, information and knowledge.

The case organisation DTU Campus Service is an organisation that has been taking care of the operation and maintenance of campuses for many years; therefore, it possesses huge amounts of knowledge that can be used in the new construction projects. Over the last years the importance of utilizing the existing FM knowledge has become apparent. For this reason, the management of the organisation has developed and established different tools and processes that facilitate the sharing of the existing knowledge throughout the organisation or within the departments, as well as the interdepartmental transfer of knowledge, from the FM unit to the project management of the new constructions. However, during the research it has been discovered that the case organisation has given more attention to the interaction activities, through the formation of a phase-gate project model and the development of several ICT-based systems, without focusing much on the collaboration activities within the organisation. This lack of collaboration and universal objectives within the case organisation creates several issues that lead to inefficient KT and frustration between the participants and impose the formation of a KM strategy.

Knowledge transfer within the case organisation has improved over the last years, and the personnel are becoming aware of the importance of the knowledge transfer activities. The FM
section leaders have created design standards to facilitate knowledge transfer from O&M department to the new constructions, which ensure that the FM requirements regarding the new projects are set for the project team to consider during the design phases. On the other hand, project managers ensure that all the available data and information that derive throughout every project phase are communicated to the FM sections, through the use of an ICT-based project-web. However, there is still plenty of room for improvement and the previous section includes a number of specific recommendations of relevance for the case organisation, but also for other FM organisations.

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